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(54) **SYSTEMS, APPARATUSES, OR COMPONENTS FOR ELECTROLYTIC CORROSION PROTECTION OF ELECTRONIC ELEMENT TESTING APPARATUSES**

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G01R 1/04	(2006.01)

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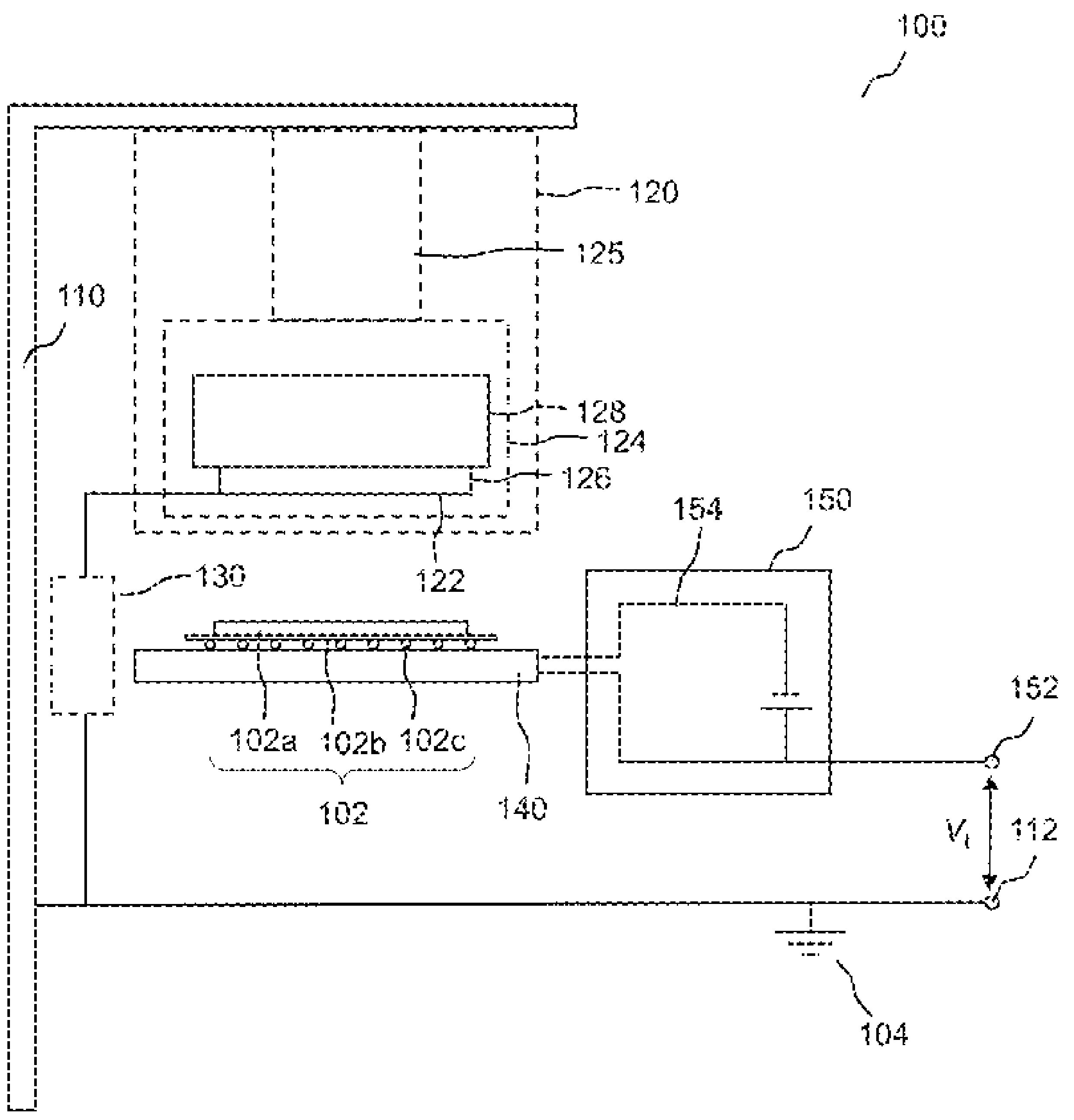
(57) **ABSTRACT**

An apparatus includes a tester chassis connected to a chassis electric reference potential for electrostatic discharge grounding of the tester chassis; a thermal head assembly coupled to the tester chassis, the thermal head assembly having a metallic thermal contact surface; and an electrical insulation arrangement disposed between the metallic thermal contact surface and the chassis electric reference potential to electrically insulate the metallic thermal contact from the chassis electric reference potential. An electrolytic corrosion protection system for the apparatus and a cable assembly for the apparatus.

20 Claims, 9 Drawing Sheets



(58) **Field of Classification Search**
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See application file for complete search history.

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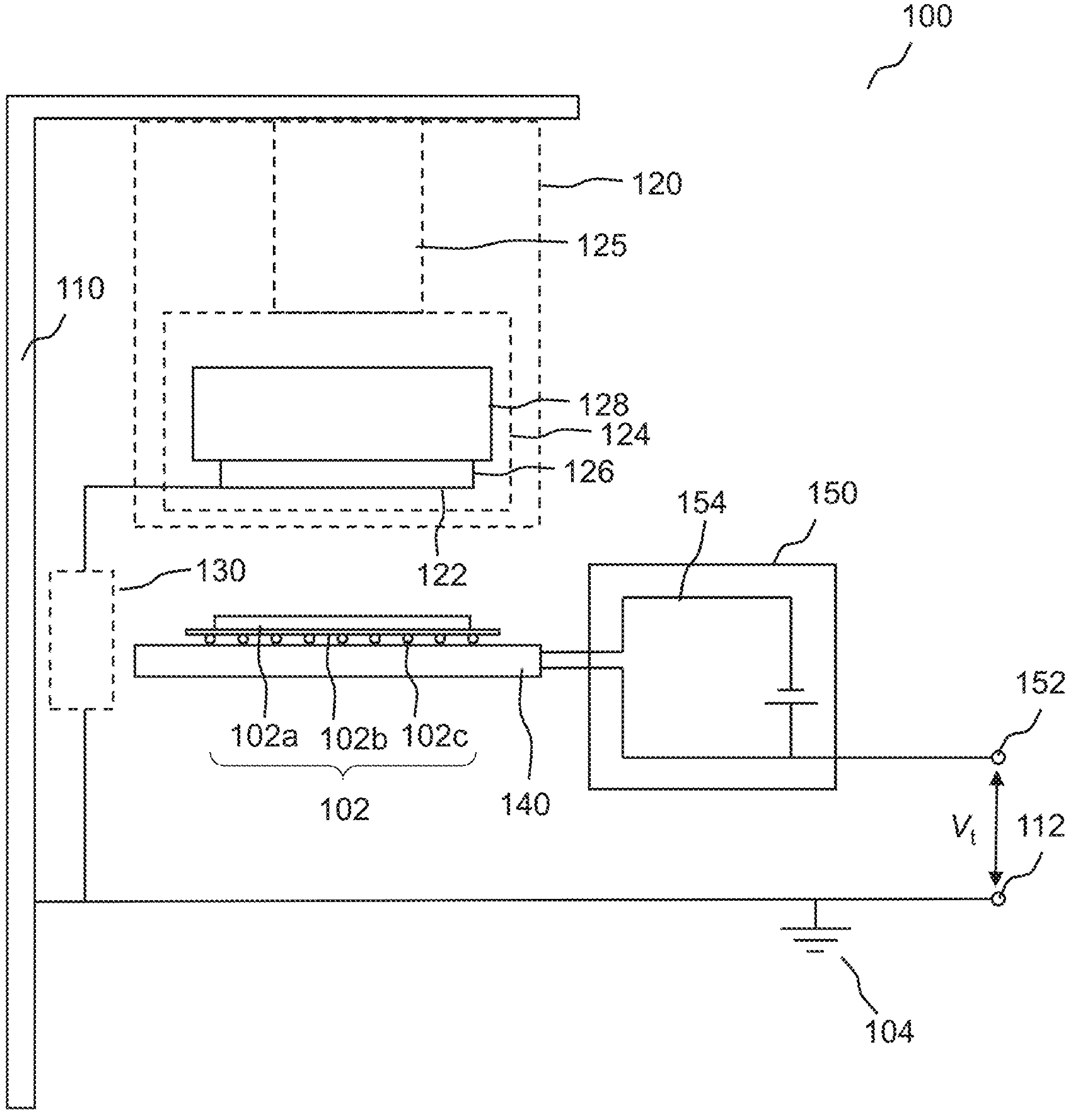
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120
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110
128
124
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102a
102b
102c
102
140
V_t
112
104

FIG. 1

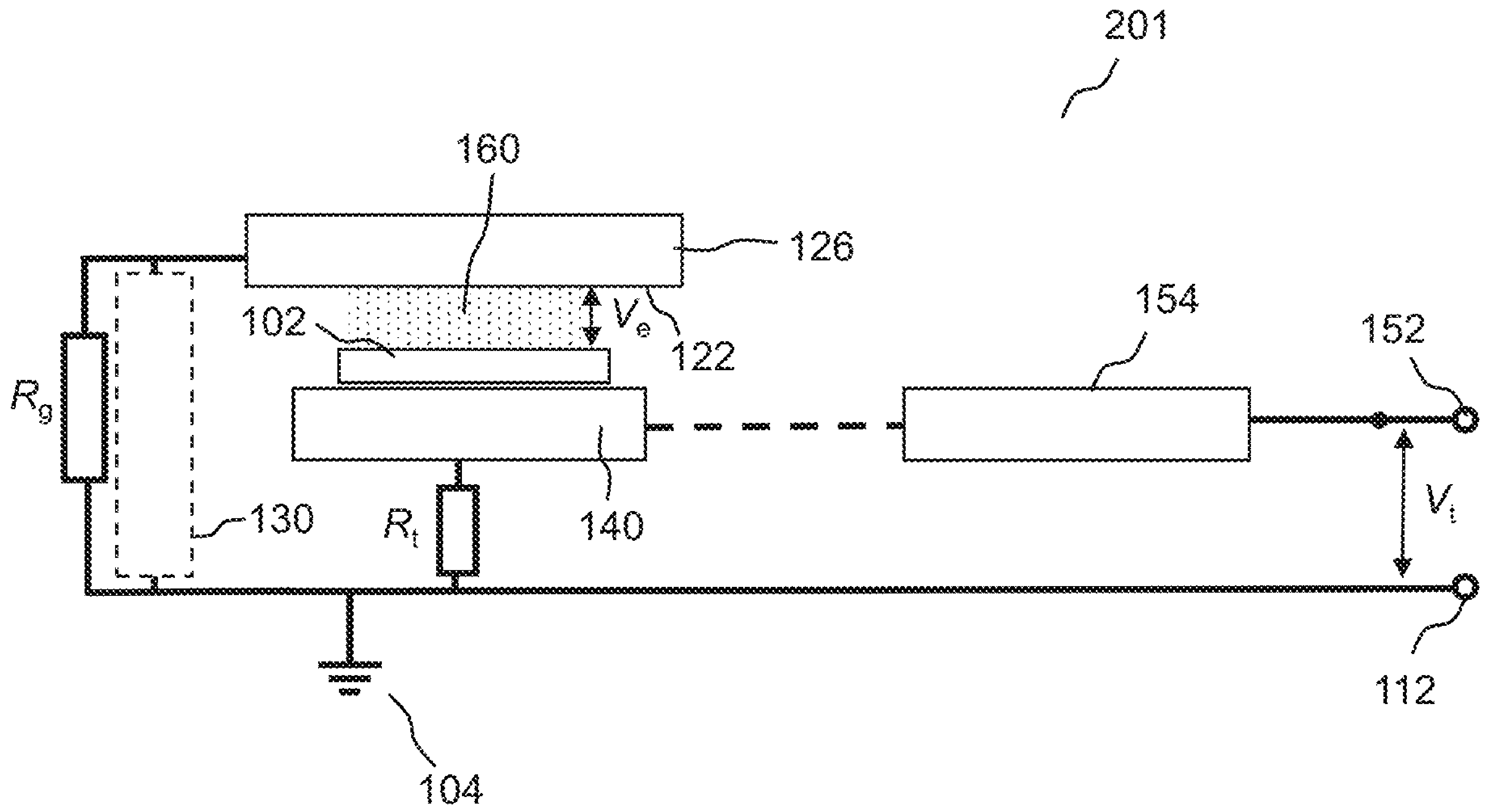
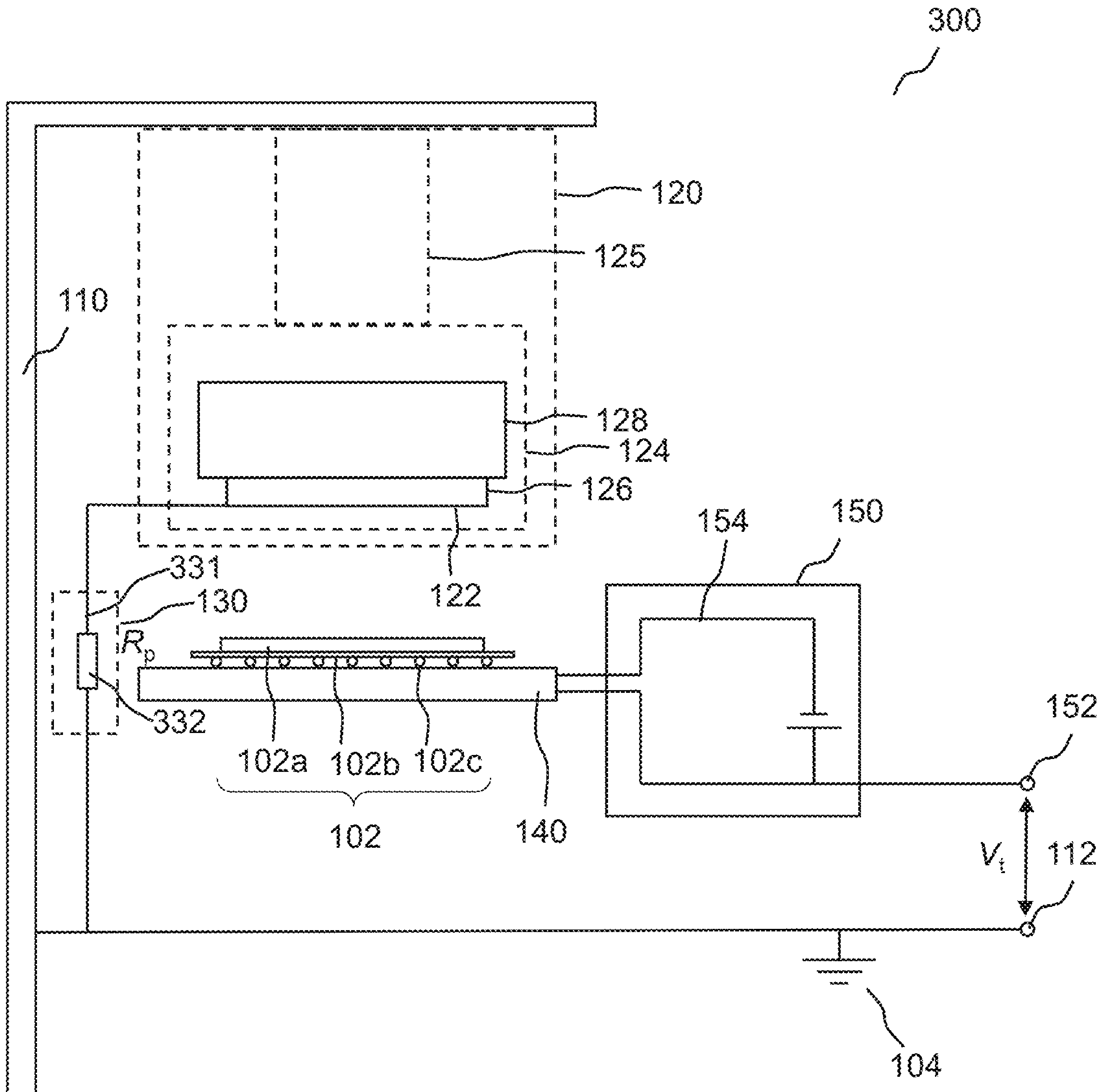


FIG. 2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126
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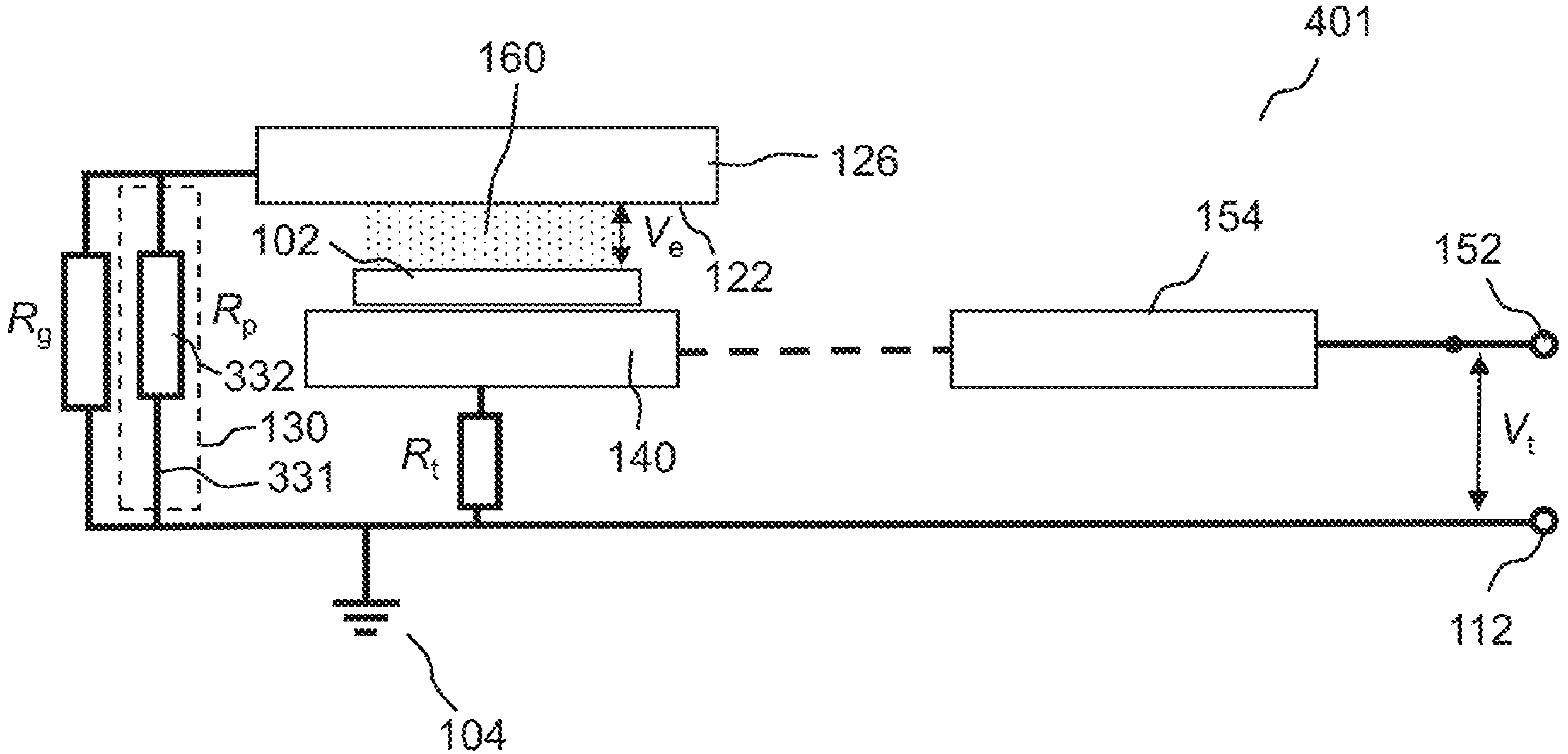
104

FIG. 3


401
160
126
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R_g
R_p
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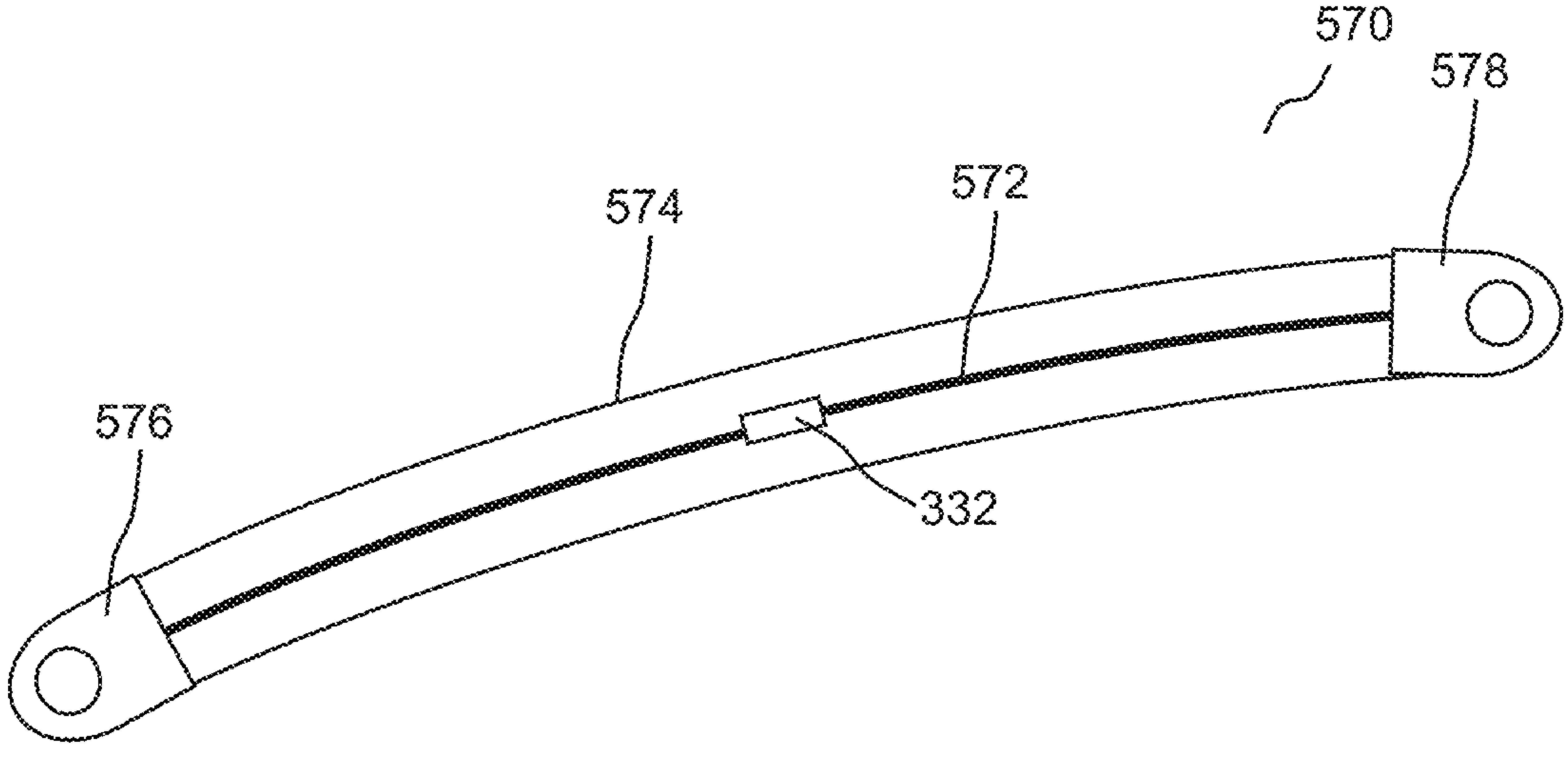
V_t
112
104

FIG. 4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572
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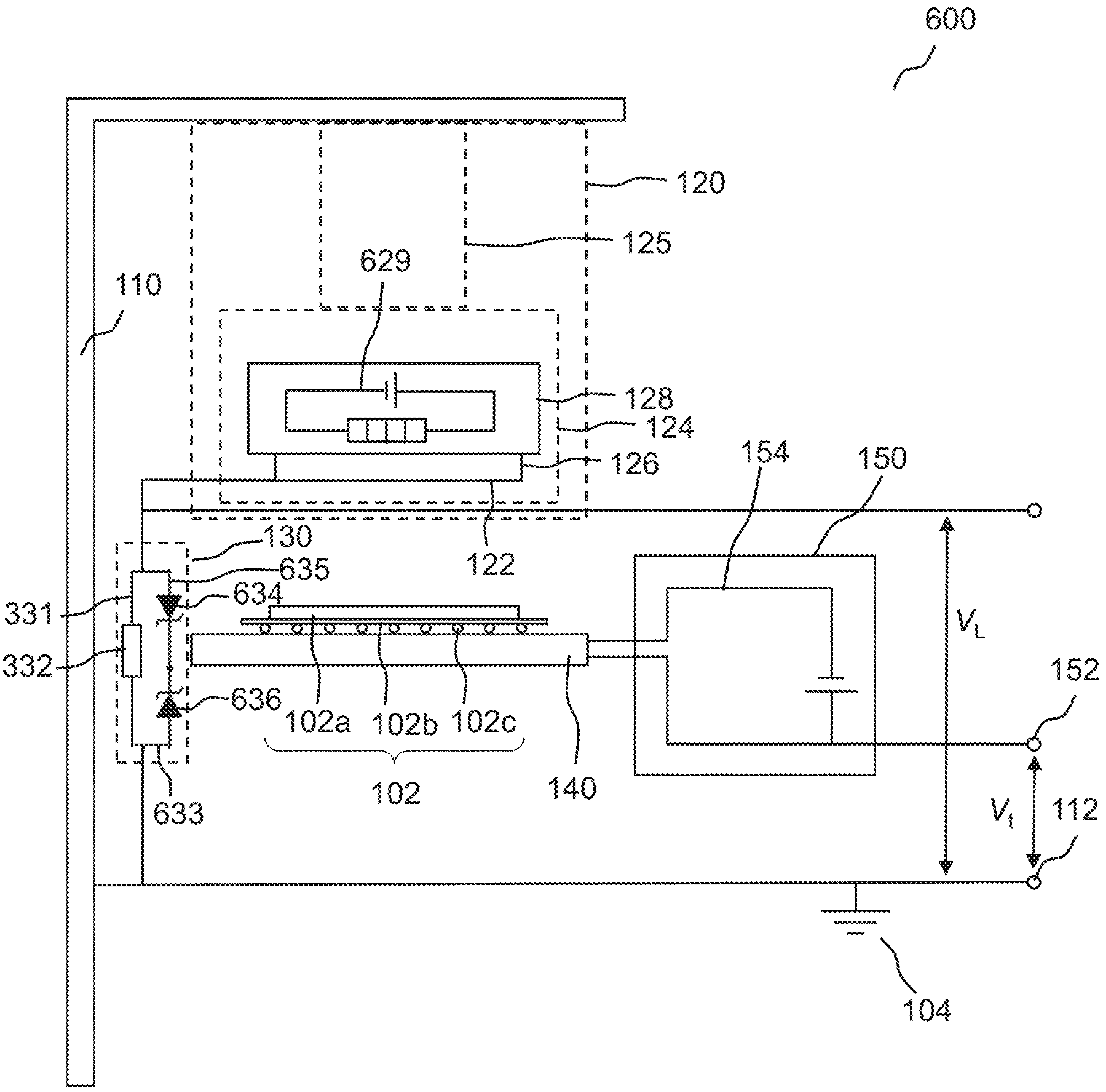
332

FIG. 5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122
130
635
331
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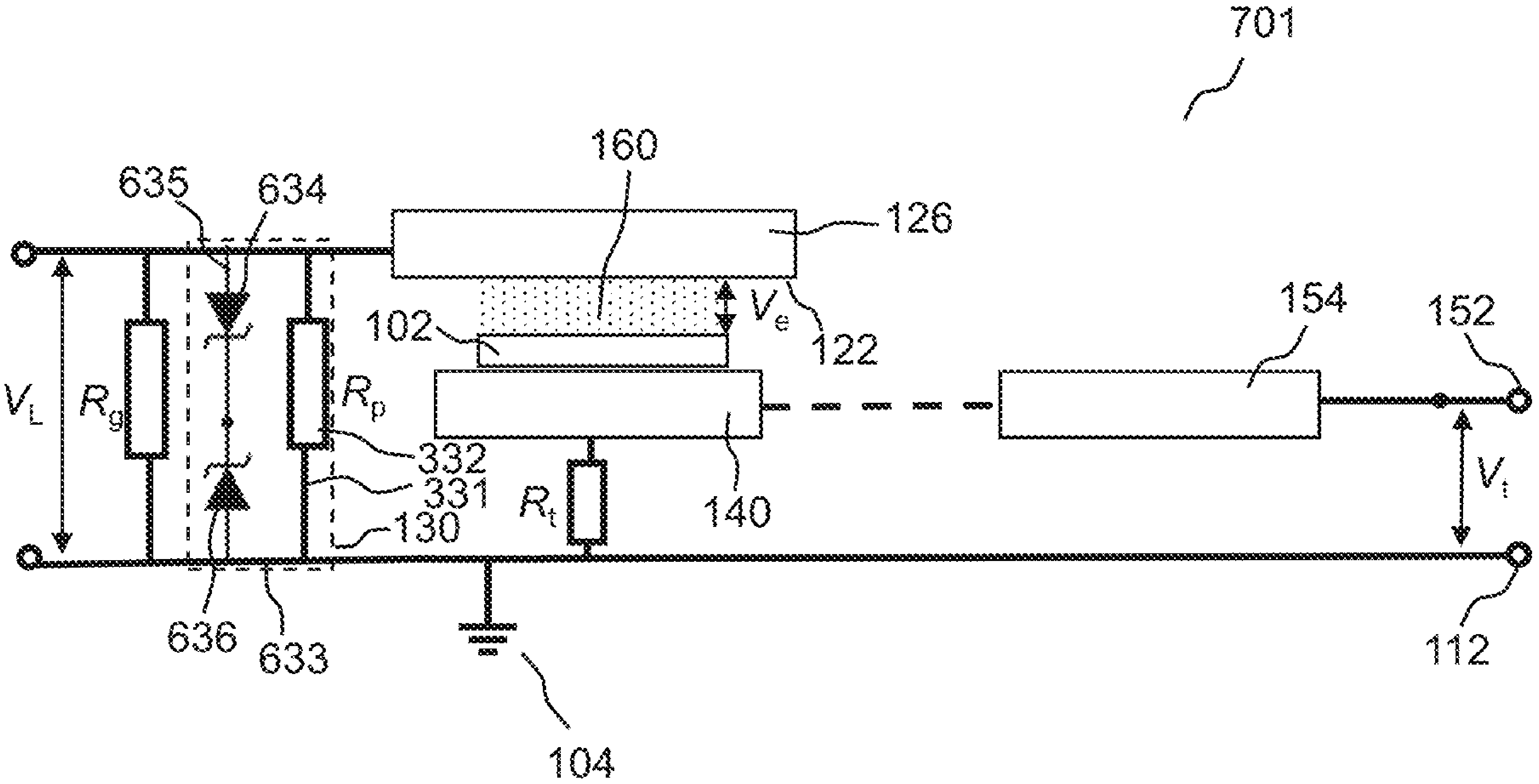
332
636
102a
102b
102c
102
140
633
V_L
152
V_t
112
104

FIG. 6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634
102
V_e
122
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152
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140
V_t
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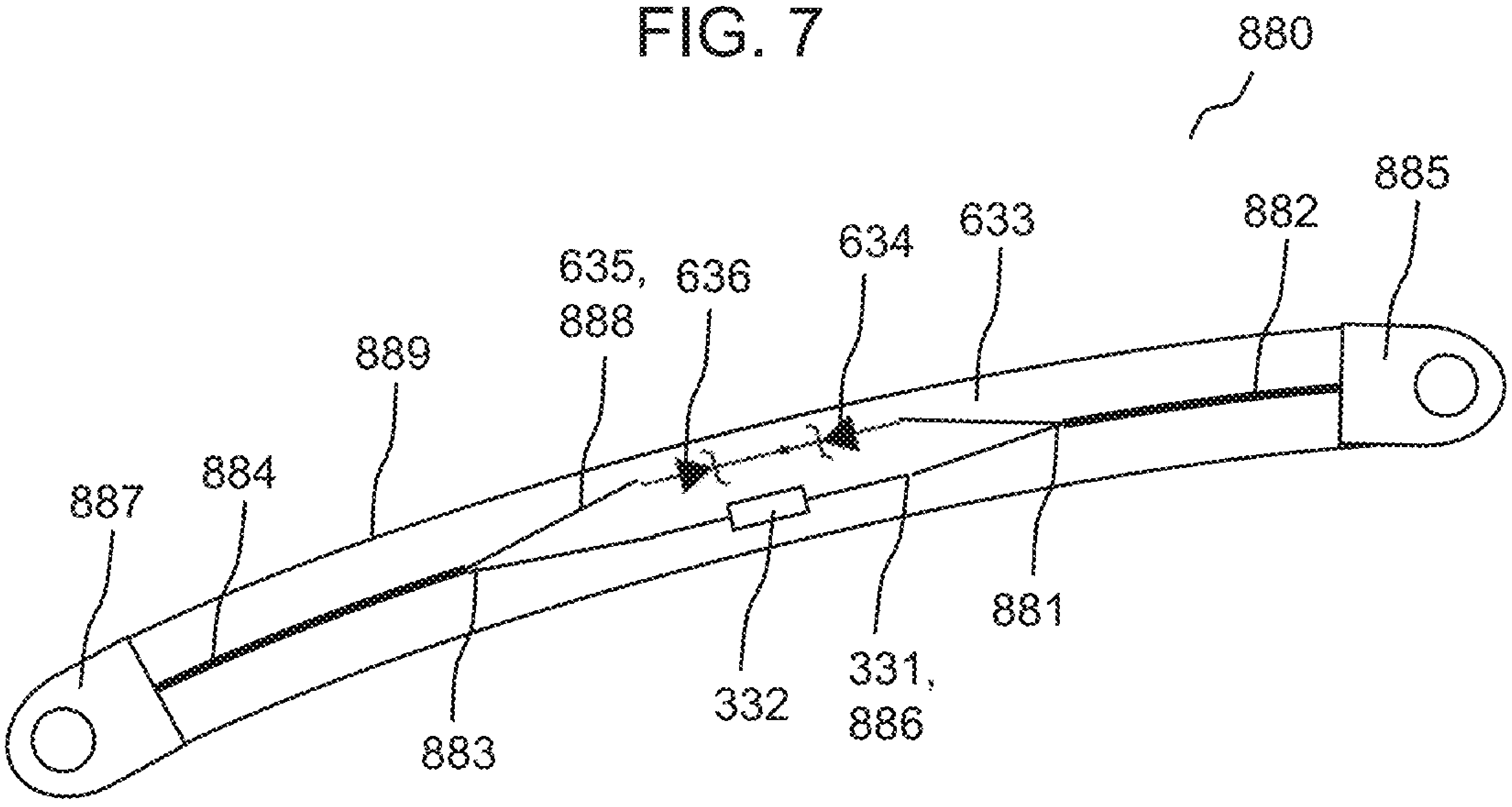
633
104
112

FIG. 7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635, 888
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887
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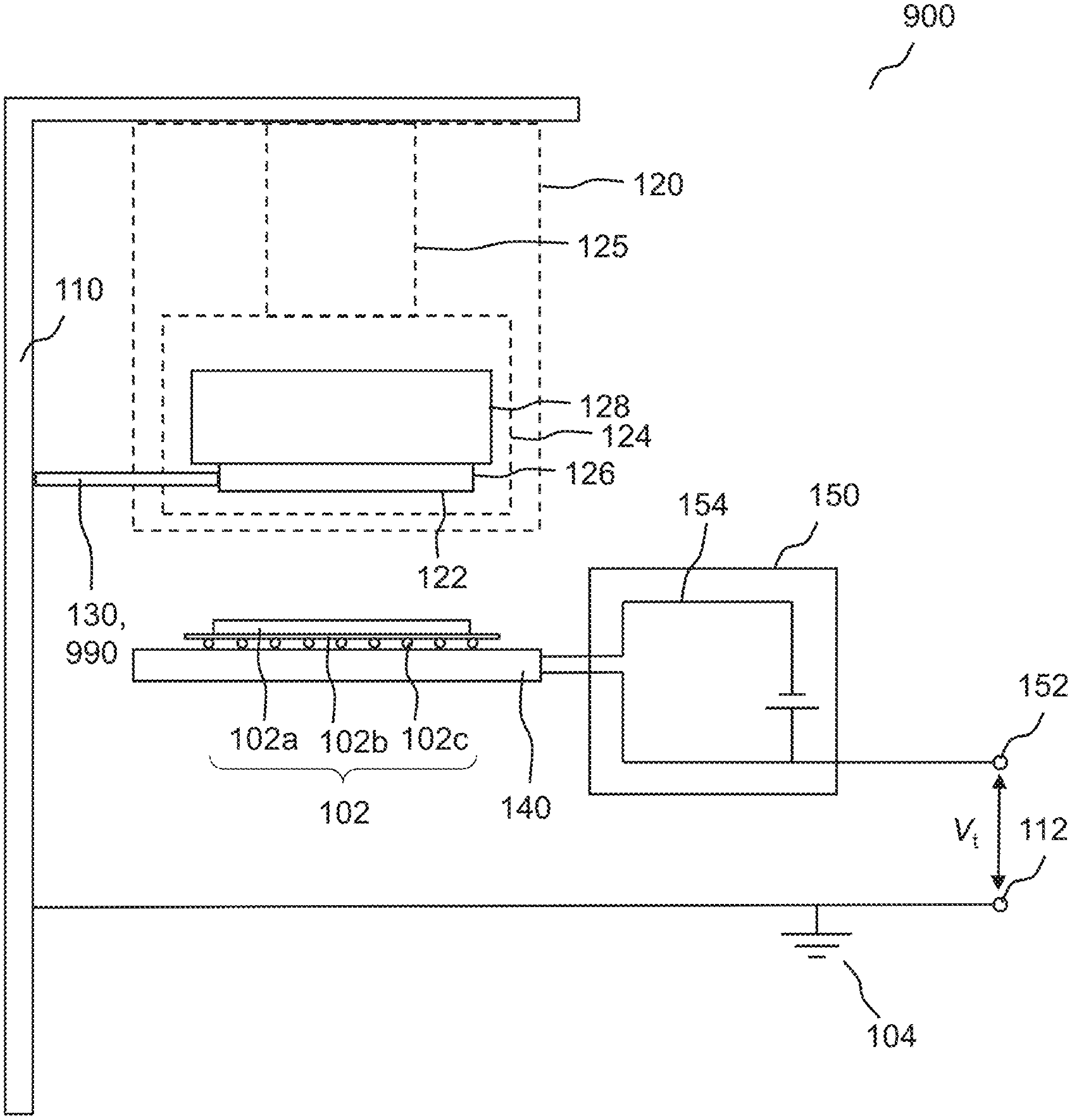
331, 886
332
883

FIG. 8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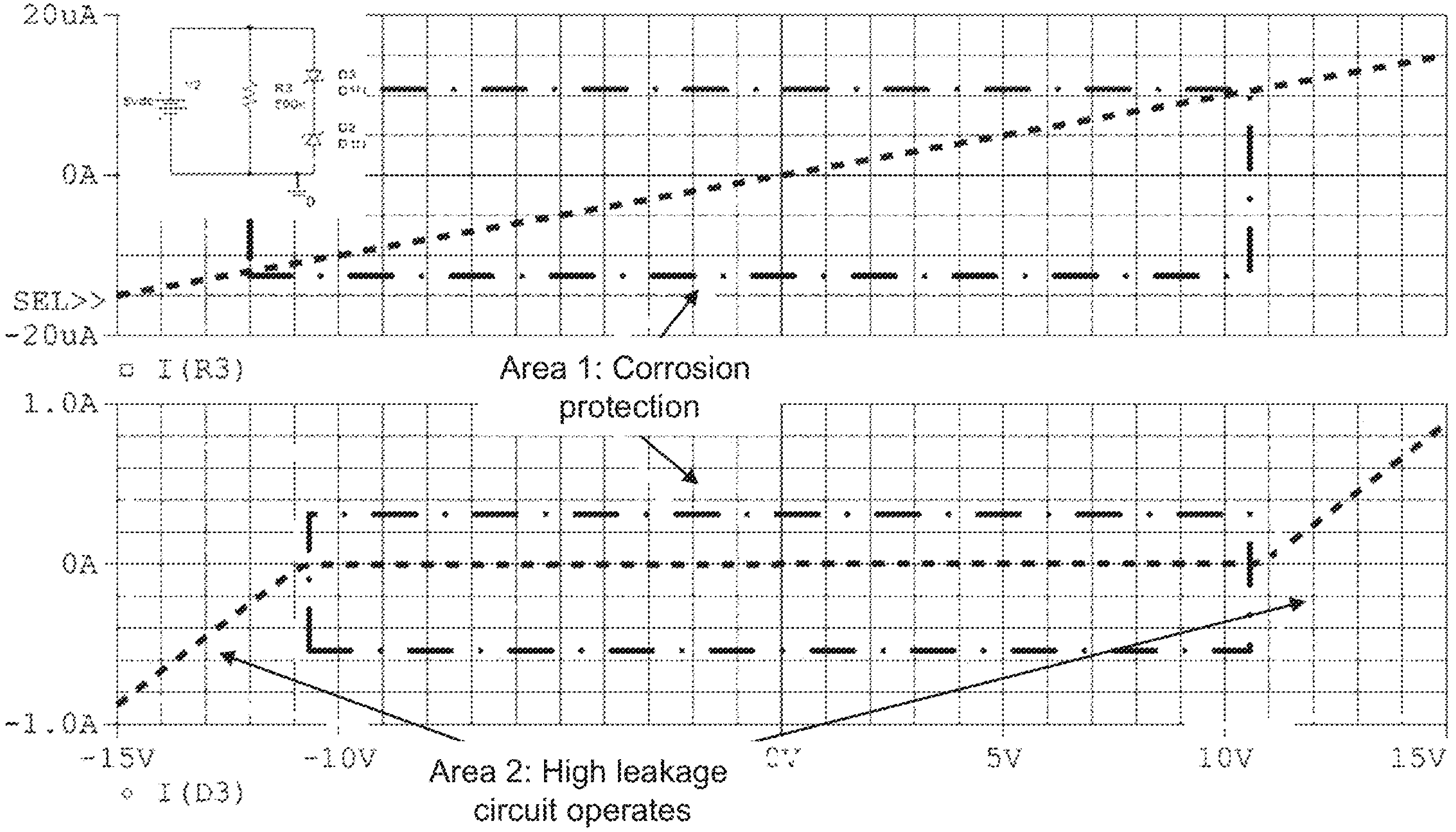
120
125
110
128
124
126
154
150
122
130,
990
152
102a
102b
102c
102
140
V_t
112
104

FIG. 9



Area 1: Corrosion protection

Area 2: High leakage circuit operates

FIG. 10

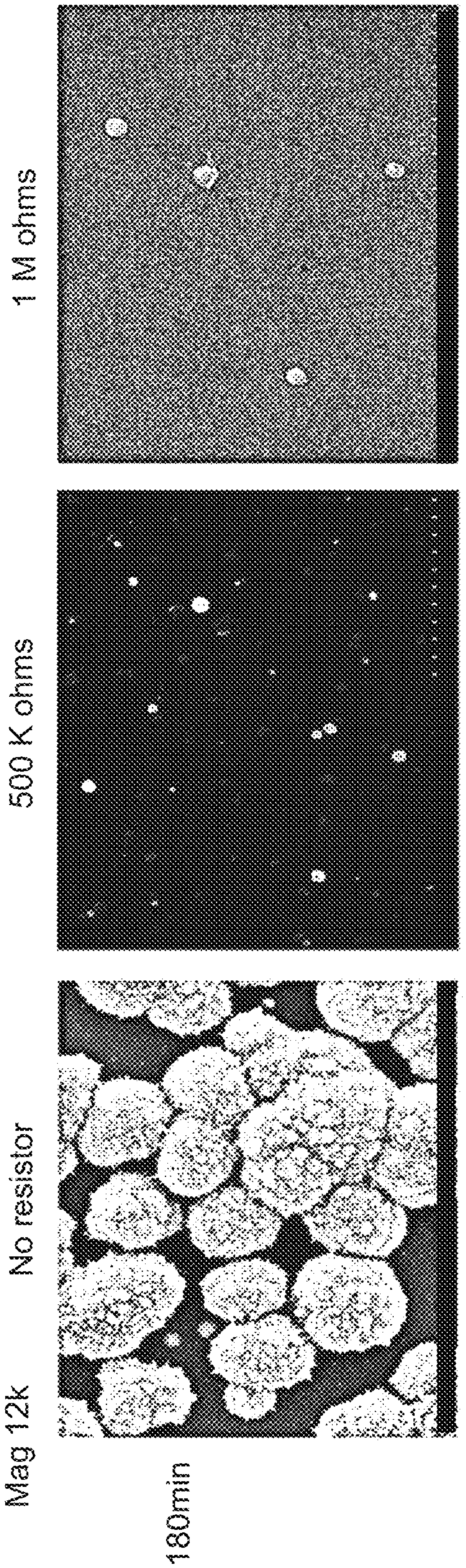


FIG. 11

SYSTEMS, APPARATUSES, OR COMPONENTS FOR ELECTROLYTIC CORROSION PROTECTION OF ELECTRONIC ELEMENT TESTING APPARATUSES

TECHNICAL FIELD

Various aspects relate generally to an electrolytic corrosion protection system for an electronic element testing apparatus, or an electronic element testing apparatus with electrolytic corrosion protection, or a cable assembly for use in the electrolytic corrosion protection system, or a cable assembly for use in the electronic element testing apparatus for electrolytic corrosion protection.

BACKGROUND

In assembly and test factories, it is known that stain-on-die issues on device under test, DUT, (e.g. bare die products) is due to leakage current from the marginal tester board causing electrolytic corrosion phenomena on the nickel-plated pedestal as it engages the DUT with a layer of liquid thermal interface material, LTIM, therebetween during testing. Corrosion on the pedestal gets aggravated as more units get tested leaving a more pronounced stain signature on the DUT. This resulted in a significant number of rejected units and multiple quality issues.

Attempts to resolve the issue include using an automatic tester leaked detection script to identify leaky tester card, i.e. failed hardware, and apply diagnostic to repair the suspected leaky tester card. However, the automatic tester leaked detection script is too slow, and slow corrosion still happen. Subsequent repair and fixing of tester card is also not practical as it results in factory lines down. Further, it is also not practical to delay repair and/or fixing of the tester card till natural lifespan of the tester card as the natural lifespan is more than 10 years.

Alternate attempts to resolve the issued include changing the pedestal plating from nickel to chrome as data has shown that chrome plating has better electrolysis corrosion resistance as compared to nickel plating. However, chrome plating process is more complicated than nickel plating, and common failures include chrome protrusions, holes, scratches, which can result in faster corrosion. Further, there are different chrome plating recipe and no high-quality chrome plating recipe is available. Hence, chrome plating is not presently feasible.

BRIEF DESCRIPTION OF THE DRAWINGS

Throughout the drawings, it should be noted that like reference numbers are used to depict the same or similar elements, features, and structures. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating aspects of the disclosure. In the following description, some aspects of the disclosure are described with reference to the following drawings, in which:

FIG. **1** shows a testing apparatus in a schematic view according to various aspects;

FIG. **2** shows an electrolytic corrosion protection system for the testing apparatus of FIG. **1** according to various aspects;

FIG. **3** shows a testing apparatus in a schematic view according to some aspects of the disclosure;

FIG. **4** shows an electrolytic corrosion protection system for the testing apparatus of FIG. **3** according to some aspects of the disclosure;

FIG. **5** shows a cable assembly according to an aspect of the disclosure;

FIG. **6** shows a testing apparatus in a schematic view according to some aspects of the disclosure;

FIG. **7** shows an electrolytic corrosion protection system for the testing apparatus of FIG. **6** according to some aspects of the disclosure;

FIG. **8** shows a cable assembly according to an aspect of the disclosure;

FIG. **9** shows a testing apparatus in a schematic view according to some aspects of the disclosure;

FIG. **10** shows simulation results in the form of current vs voltage curve based on the electrolytic corrosion protection system of FIG. **7**; and

FIG. **11** shows experimental results based on the electrolytic corrosion protection system of FIG. **4**.

DESCRIPTION

The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and aspects in which the disclosure may be practiced. One or more aspects are described in sufficient detail to enable those skilled in the art to practice the disclosure. Other aspects may be utilized and structural, logical, and/or electrical changes may be made without departing from the scope of the disclosure. The various aspects of the disclosure are not necessarily mutually exclusive, as some aspects can be combined with one or more other aspects to form new aspects. Various aspects are described in connection with methods and various aspects are described in connection with devices. However, it may be understood that aspects described in connection with methods may similarly apply to the devices, and vice versa.

The term “exemplary” or “example” may be used herein to mean “serving as an example, instance, or illustration”. Any aspect or design described herein as “exemplary” is not necessarily to be construed as preferred or advantageous over other aspects or designs.

The terms “at least one” and “one or more” may be understood to include a numerical quantity greater than or equal to one (e.g., one, two, three, four, [. . .], etc.). The term “a plurality” may be understood to include a numerical quantity greater than or equal to two (e.g., two, three, four, five, [. . .], etc.).

The phrase “at least one of” with regard to a group of elements may be used herein to mean at least one element from the group consisting of the elements. For example, the phrase “at least one of” with regard to a group of elements may be used herein to mean a selection of: one of the listed elements, a plurality of one of the listed elements, a plurality of individual listed elements, or a plurality of a multiple of listed elements.

The words “plural” and “multiple” in the description and in the claims expressly refer to a quantity greater than one. Accordingly, any phrases explicitly invoking the aforementioned words (e.g., “a plurality of (objects)”, “multiple (objects)”) referring to a quantity of objects expressly refers more than one of the said objects. The terms “group (of)”, “set (of)”, “collection (of)”, “series (of)”, “sequence (of)”, “grouping (of)”, etc., and the like in the description and in the claims, if any, refer to a quantity equal to or greater than one, i.e. one or more.

The terms "processor" or "controller" as, for example, used herein may be understood as any kind of entity that allows handling data. The data may be handled according to one or more specific functions executed by the processor or controller. Further, a processor or controller as used herein may be understood as any kind of circuit, e.g., any kind of analog or digital circuit. A processor or a controller may thus be or include an analog circuit, digital circuit, mixed-signal circuit, logic circuit, processor, microprocessor, Central Processing Unit (CPU), Graphics Processing Unit (GPU), Digital Signal Processor (DSP), Field Programmable Gate Array (FPGA), integrated circuit, Application Specific Integrated Circuit (ASIC), etc., or any combination thereof. Any other kind of implementation of the respective functions, which will be described below in further detail, may also be understood as a processor, controller, or logic circuit. It is understood that any two (or more) of the processors, controllers, or logic circuits detailed herein may be realized as a single entity with equivalent functionality or the like, and conversely that any single processor, controller, or logic circuit detailed herein may be realized as two (or more) separate entities with equivalent functionality or the like.

The term "memory" detailed herein may be understood to include any suitable type of memory or memory device, e.g., a hard disk drive (HDD), a solid-state drive (SSD), a flash memory, etc.

Differences between software and hardware implemented data handling may blur. A processor, controller, and/or circuit detailed herein may be implemented in software, hardware and/or as hybrid implementation including software and hardware.

The term "system" (e.g., an electrolytic corrosion protection system, etc.) detailed herein may be understood as a set of interacting elements, wherein the elements can be, by way of example and not of limitation, one or more mechanical components, one or more electrical components, one or more instructions (e.g., encoded in storage media), and/or one or more processors, and the like.

The phrase "electric reference potential" used in "chassis electric reference potential", "test circuit electric reference potential", and the like, may be used herein to mean a reference point from which a potential/voltage may be measured along respective conductive path for flow of current or electricity.

The phrase "electrostatic discharge grounding" used with regard to a "tester chassis" may include any suitable way of grounding the "tester chassis" to discharge built-up static charge for controlling static charge on the tester chassis.

The phrase "electrical insulation arrangement" used with regard to a "metallic thermal contact surface" and the "chassis electric reference potential" may be understood as one or more materials or elements or components placed (e.g. arranged, disposed, positioned, ordered, etc.) anywhere between the "metallic thermal contact surface" and the "chassis electric reference potential" to use as a tangible barrier for separating the "metallic thermal contact surface" and the "chassis electric reference potential" so as to reduce electrical conduction and/or does not allow electrical energy to pass through, wherein the materials or elements or components can be, by way of example and not of limitation, one or more mechanical components, one or more electrical components, and the like. The phrase "electrically insulated" may be construed accordingly.

The phrase "electric potential difference" used with regards to "chassis electric reference potential", "test circuit electric reference potential", and the like, may be used herein to mean a difference in electric potential (or voltage) between the two points.

The term "circuit" used in "test circuit", "heater circuit", "parallel circuit", and the like, may be used herein to mean a network of interconnecting electrical components for flow of current or electricity. Further, the "circuit" may be an uncomplete (i.e. partial or a portion of) or a fully completed circuit, an open circuit, and/or a closed circuit. The phrase "parallel circuit" may be used herein to mean two or more paths connected to the same electrically common points to form the network, each path having one or more electrical components connected between the same electrically common points.

The phrase "circuit ground" used with regards to "test unit", "test circuit", and the like, may be used herein to mean a single neutral reference point on the specific circuit measuring zero (0) volts, serving as a reference point for the specific circuit from which voltages at other points of the specific circuit are measured.

The phrases "circuit path", "first path", "second path" may be used herein to mean a route or course for current or electricity to flow from one point to another point. Accordingly, the phrases "circuit path", "first path", "second path" may be used herein to mean a portion of a circuit between two points of the circuit.

The terms "node" with regards to "circuit" may be used herein to mean a point of connection between two or more paths of the "circuit". Further, the terms "node" with regards to "first wire part" and "second wire part" may be used herein to mean a physical joint formed by connecting physical ends of the "first wire part" and "second wire part" together.

The terms "cable" or "cable assembly" may be used herein to mean physical cord-like component for connecting two physical devices. Accordingly, the "cable" or "cable assembly" may be an assembly of one or more wires running alongside each other and/or bundled together to form the physical cord of insulated electrical conductor.

The phrases "wire part", "wire segment", may be used herein to mean physical strand-like components which may serve as a core of the "cable" or "cable assembly". Further, the "wire part", "wire segment", may be used herein to mean a section or a portion or a segment of the core of the "cable" or "cable assembly".

The phrase "hardware element" may be used herein to mean physical machine (or mechanical) element or an elementary (or basic) mechanical part including, but not limited to, a space, a washer, a fastener, a linkage, a connector, a coupling, etc.

The phrase "non-conductive" may be used herein to mean not capable of conducting electricity or have very low electrical conductivity. Further, the phrase "non-conductive" with regards to "hardware element", "spacer", "washer", "fastener", "linkage", "connector", "coupling", and the like, may be used herein to mean that the respective component is configured to be "non-conductive", for example by being made of "non-conductive" material.

The phrase "joint or mechanical connection" may be used herein to mean a point or a place at which two physical components/objects/parts are joined or united or place in contact to each other.

FIG. **1** shows a testing apparatus **100** in a schematic view, according to various aspects. The testing apparatus **100** may be for functional testing of a device under test, DUT **102**, to ensure performance meets a defined set of quality criteria, or for quality control purposes, prior to assembly and/or delivery. The DUT **102** may be an electronic device, including but not limited to, a semiconductor die, a semiconductor component, a semiconductor package, an integrated circuit, or an electronic component. In FIG. **1**, as a non-limiting example, the DUT **102** is illustrated with a silicon die **102***a* on a substrate **102***b* having a plurality of contact elements **102***c*. It is understood that the DUT **102** may be in various configurations, forms, arrangements not shown.

According to various aspect, the testing apparatus **100** may include a tester chassis **110**. The tester chassis **110** may be a frame, a body, and/or a casing of the testing apparatus **110**. Further, the tester chassis **110** may be connected to a chassis electric reference potential **112**. The chassis electric reference potential **112** may be for electrostatic discharge grounding of the tester chassis **110**. According to various aspect, the testing apparatus **100** may include a grounding component connecting the tester chassis **110** to the earth ground **104** serving as the chassis electric reference potential **112**. Hence, the chassis electric reference potential **112** may be based on the earth ground **104** as a reference potential.

According to various aspect, the testing apparatus **100** may include a thermal head assembly **120**. The thermal head assembly **120** may be coupled to the tester chassis **110**. During testing of the DUT **102** with the testing apparatus, the thermal head assembly **120** may be operable to heat and/or cool the DUT **102** to the prescribed temperature, and maintain the DUT **102** at the prescribed temperature. According to various aspect, the thermal head assembly **120** may include a metallic thermal contact surface **122**. The metallic thermal contact surface **122** may serve as a thermal interface for thermal transfer, via thermal conduction, with the DUT **102** during testing. During testing, the thermal head assembly **120** may be operable to move the metallic thermal contact surface **122** relative to the tester chassis **110** to contact or abut the DUT **102** for regulating a temperature of the DUT **102**. According to one aspect, the metallic thermal contact surface **122** may be plated with a metallic material, for example, including but not limited to, nickel plating or chrome plating.

According to various aspect, the testing apparatus **100** may include an electrical insulation arrangement **130**. The electrical insulation arrangement **130** may include an arrangement of one or more electrical components or one or more mechanical components connected between two points to serve as a tangible barrier separating the two points so as to reduce electrical conduction and/or prohibit electrical energy to pass through between the two points. Further, the electrical insulation arrangement **130** may be disposed between the metallic thermal contact surface **122** and the chassis electric reference potential **112**. Accordingly, the electrical insulation arrangement **130**, being an arrangement of one or more electrical components or one or more mechanical components, may form the tangible barrier separating the metallic thermal contact **122** and the chassis electric reference potential **112** to reduce electrical conduction and/or prohibit electrical energy to pass through between them so as to electrically insulate the metallic thermal contact **122** from the chassis electric reference potential **112**. Hence, the electrical insulation arrangement **130** may be configured to electrically insulate the metallic thermal contact **122** from the chassis electric reference potential **112**.

In a conventional testing apparatus, a nickel-plated thermal interface of the thermal head may be directly grounded to a chassis of the conventional testing apparatus via grounding cable and/or direct contact with the chassis of the conventional testing apparatus. Further, during testing, the nickel-plated thermal interface may be engaging the DUT with a layer of liquid thermal interface material, LTIM. However, when the tester card of the conventional testing apparatus is faulty resulting in leakage current to the DUT, the direct grounding of the nickel-plated thermal interface of the thermal head may create an electrolytic cell condition between the nickel-plated thermal interface of the thermal head and the DUT, whereby the LTIM may serve as the electrolyte between the nickel-plated thermal interface of the thermal head and the DUT, the leakage current may serve as the power source for the electrolytic cell condition, and the direct grounding of the nickel-plated thermal interface of the thermal head may serve as to close the electrical path to the faulty tester card. The electrolytic cell condition between the thermal interface of the thermal head and the DUT may cause electrolytic corrosion phenomena resulting in the corrosion of the nickel-plated thermal interface and staining issues on the DUT.

Various aspects of the disclosure differ from the conventional testing apparatus in that direct grounding of the thermal interface to the chassis has been replaced with the electrical insulation arrangement **130** disposed between the metallic thermal contact surface **122** and the chassis electric reference potential **112**. In doing so, the electrical insulation arrangement **130** may reduce or prohibit the current flow from the metallic thermal contact surface **122** and the chassis electric reference potential **112**. Accordingly, an electrolytic corrosion current flow from the metallic thermal contact surface **122** to the chassis electric reference potential **112** may be significantly reduced or cut. Therefore, the electrolytic reaction may be significantly reduced or eliminated, and the possible electrolytic corrosion issue of the metallic thermal contact surface **122** as well as the possible staining issue of the DUT **102** may be solved. Hence, the incorporation of the electrical insulation arrangement **130** into the testing apparatus **100** may provide a corrosion protection function for the testing apparatus **100**. Thus, various aspects may provide an electrolytic corrosion protection system for the testing apparatus **100**, or provide the testing apparatus **100** with electrolytic corrosion protection.

According to various aspect, the testing apparatus **100** may include a DUT connector **140**. The DUT connector **140** may be connectable with the DUT **102**. Accordingly, the DUT connector **140** may be configured to receive the DUT **102**. Hence, the DUT **102** may be connected or inserted or fitted to the DUT connector **140**. Further, the DUT connector **140** may be configured for electrical connection with the DUT **102**. Accordingly, the DUT **102** may establish an electrical connection with the DUT connector **140** when the DUT **102** is connected to the DUT connector **140**. According to various aspect, the thermal head assembly **120** may be operable to move the metallic thermal contact surface **122** to contact the DUT **102** when the DUT **102** is connected to the DUT connector **140**. Accordingly, the DUT connector **140** may be disposed with respect to the thermal head assembly **120** in a manner such that the DUT **102** connected to the DUT connector **140** may be in a movement path of the metallic thermal contact surface **122**. According to one aspect, the DUT connector **140** may be in the form of a socket with a plurality of pins to contact with the plurality of contact elements **102***c* of the DUT **102**. Further, in some aspects, the thermal head assembly **120** may be configured to move the metallic thermal contact surface **122** in an up and down movement along a vertical movement axis. Accordingly, the DUT connector **140** may be disposed directly under the metallic thermal contact surface **122** along the vertical movement axis such that an exposed surface of the DUT may be directly facing the metallic thermal contact surface **122**.

According to various aspects, the testing apparatus **100** may include a test unit **150**. The test unit **150** may be connected to the DUT connector **140**. Accordingly, when the DUT **102** is connected to the DUT connector **140**, the test unit **150** may communicate with the DUT **102** via the DUT connector **140**. Further, the test unit **150** may be configured to run test programs for performing functional testing of the DUT connected to the DUT connector **140**. Accordingly, the test unit **150** may communicate with the DUT **102** by sending any one or a combination of a signal, a voltage, a current, or data via the DUT connector **140** connecting the DUT **102** to the test unit **150**. Further, the test unit **150** may include a test circuit electric reference potential **152**. The test circuit electric reference potential **152** may serve as a circuit ground for the test unit **150**. Accordingly, the test unit **150** may use the test circuit electric reference potential **152** as the neutral reference point, i.e. the zero (0) volts reference point, for measuring voltage or potential within the test unit **150** to operate the test unit **150** for running the test programs and/or communicating with the DUT **102**.

According to various aspects, the test unit **150** may include a test circuit **154**. The test circuits **154** may include one or more electrical components, one or more electronic components, one or more controllers, one or more processors, and/or one or more memories for running test programs and/or communicating with the DUT **102**. In order for the test circuit **154** to communicate and run test programs on the DUT **102**, the DUT **102** may be connected to the test circuit **154**. Accordingly, the test circuit **154** may be configured to receive the DUT **102** so as to connect the DUT **102** to the test circuit **154**. As an example, the DUT **102** may be connected to the test circuit **154** of the test unit **150** via the DUT connector **140**. Further, the test circuit electric reference potential **152** of the test unit **150** may serve as the circuit ground for the test circuit **154** of the test unit **150**. Accordingly, the test circuit **154** may include the test circuit electric reference potential **152**. Hence, the test circuit electric reference potential **152** may serve as the neutral reference point, i.e. the zero (0) volts reference point, for the test circuit **154** from which voltages or potentials at other points of the test circuit **154** may be measured.

According to various aspects, an electric potential difference, V_t, may exist between the chassis electric reference potential **112** and the test circuit electric reference potential **152**. Accordingly, the test circuit electric reference potential **152** may be at a different voltage or potential than the chassis electric reference potential **112**, when using the chassis electric reference potential **112** as a reference for comparison. Hence, the chassis electric reference potential **112** and the test circuit electric reference potential **152** may be unique reference potential that do not form a common ground or common reference potential. Thus, a voltage or potential may be measured across the chassis electric reference potential **112** and the test circuit electric reference potential **152**.

Due to the electric potential difference, V_t, between the chassis electric reference potential **112** and the test circuit electric reference potential **152**, the likelihood of creating the electrolytic cell condition between the nickel-plated thermal interface of the thermal head and the DUT may be aggravated when there is a leakage current from the test unit **150** that is faulty. According to various aspects, the electrical insulation arrangement **130** disposed between the metallic thermal contact surface **122** and the chassis electric reference potential **112** may reduce or prohibit the current flow from the metallic thermal contact surface **122** and the chassis electric reference potential **112** so as to significantly reduce or cut the electrolytic corrosion current flow from the metallic thermal contact surface **122** to the chassis electric reference potential **112**. Therefore, the electrolytic reaction may be significantly reduced or eliminated, and the possible electrolytic corrosion issue of the metallic thermal contact surface **122** as well as the possible staining issue of the DUT **102** may be solved.

According to some aspects, the thermal head assembly **120** may include a head unit **124**. The head unit **124** may include a contact member **126** and a heater **128**. According to some aspects, the metallic thermal contact surface **122** may be an exposed surface of the contact member **126**. The contact member **126** may be made of metallic material or may be plated or coated with metallic material so as to form the metallic thermal contact surface **122**. In some aspects, the metallic material may be nickel or chrome.

According to some aspects, the heater **128** may be coupled to the contact member **126**. The heater **128** may be configured to heat and/or cool the contact member **126** so as to control a temperature of the contact member **126** for thermal conduction with the DUT **102** via the metallic thermal contact surface **122** for regulating the temperature of the DUT **102** during testing. Accordingly, the heater **128** may be coupled to the contact member **126** in a manner so as to be capable of heating and/or cooling the contact member **126** for the metallic thermal contact surface **122** to be served as a thermal interface for thermal transfer, via thermal conduction, with the DUT **102** during testing. In some aspects, the heater **128** may be an electric heater, a non-electric heater, a fluid based heater, or the like. In some aspects, the metallic thermal contact surface **122** may be on a first side of the contact member **126**. For example, the metallic thermal contact surface **122** may be on a side of the contact member **126** that may be exposed and/or facing (or directed towards) the DUT **102** when the DUT **102** is connected to the DUT connector **140**. Further, the heater **128** may be coupled to a second side of the contact member **126**. The first side and the second side may be different sides of the contact member **126**. According to an aspect, the first side and the second side may be opposite sides of the contact member **126**. For example, when the DUT **102** is connected to the DUT connector **140**, the first side of the contact member **126** may be exposed and/or facing (or directed towards) the DUT **102** and the second side of the contact member **126** may be opposite the first side and may be directed away from the DUT **102**.

According to some aspects, the contact member **126** and the heater **128** may be integrally coupled together. Accordingly, the contact member **126** and the heater **128** may be joined together in such a way so as to form the head unit **124** as a single unit. Therefore, the contact member **126** and the heater **128** may be movable together as a single whole relative to the tester chassis **110** for moving the metallic thermal contact surface **122** to contact or abut the DUT **102** when the DUT **102** is connected to the DUT connector **140**. Hence, the thermal head assembly **120** may be operable to move the head unit **124** (or the contact member **126** and the heater **128** synchronously) relative to the tester chassis **110** so as to move the metallic thermal contact surface **122** for contacting or abutting the DUT **102** when the DUT **102** is connected to the DUT connector **140**.

According to some aspects, the thermal head assembly **120** may include an actuator **125**. The head unit **124** may be coupled to the actuator **125**. Accordingly, the actuator **125** may be configured to actuate and move the head unit **124** (or the contact member **126** and the heater **128** synchronously) relative to the tester chassis **110** for moving the metallic thermal contact surface **122** to contact or abut the DUT **102** when the DUT **102** is connected to the DUT connector **140**. According to an aspect, the actuator **125** may be connected between the tester chassis **110** and the head unit **124** so as to be operable to move the head unit **124** (or the contact member **126** and the heater **128** synchronously) relative to the tester chassis **110** for moving the metallic thermal contact surface **122** to contact or abut the DUT **102** when the DUT **102** is connected to the DUT connector **140**.

FIG. **2** shows an electrolytic corrosion protection system **201** for the testing apparatus **100** of FIG. **1** according to various aspects. In FIG. **2**, the electrolytic corrosion protection system **201** is illustrated as a circuit diagram to show the electrical connections between the various components of the testing apparatus **100** of FIG. **1** to provide electrolytic corrosion protection against the electrolytic cell conditions within the testing apparatus **100** of FIG. **1**.

According to various aspects, the electrolytic corrosion protection system **201** may include the test circuit **154**. The test circuit **154** may be configured to receive the DUT **102** and to run test programs on the DUT **102**. The DUT **102** may be connected to the test circuit **154** via the DUT connector **104**. Further, the test circuit electric reference potential **152** may serve as the circuit ground for the test circuit **154**. Accordingly, the DUT **102**, the DUT connector **104**, and the test circuit **154** may share the same test circuit electric reference potential **152**.

According to various aspects, the electrolytic corrosion protection system **201** may include the metallic thermal contact surface **122**. The metallic thermal contact surface **122** may be configured to contact the DUT **102** connected to the test circuit **154** during testing. The metallic thermal contact surface **122** may be movable relative to the tester chassis **110** such that the metallic thermal contact surface **122** may be brought into contact with the DUT **102** connected to the test circuit **154**. The metallic thermal contact surface **122** may then be operable to regulate the temperature of the DUT **102** when in contact with the DUT **102** during testing.

According to various aspects, the electrolytic corrosion protection system **201** may include the chassis electric reference potential **112**. The chassis electric reference potential **112** may be a reference potential to which the tester chassis **110** is connected for electrostatic discharge grounding of the tester chassis **110**. Since the metallic thermal contact surface **122** may be directly or indirectly coupled to the tester chassis **110**, the metallic thermal contact surface **122** may share the chassis electric reference potential **112**.

According to various aspects, the electric potential difference, V_r, may exist between the chassis electric reference potential **112** and the test circuit electric reference potential **152**. The electric potential difference, V_r, may be due to a resistance that exists between the test unit **150** (which contains the test circuit **154**) and the tester chassis **110** when they are coupled or fitted or mounted together. Accordingly, a resistance, R_r, may exist between the chassis electric reference potential **112** and the test circuit electric reference potential **152**. Thus, the resistance, R_r, between the chassis electric reference potential **112** and the test circuit electric reference potential **152** may cause the electric potential difference, V_r, to exist between the chassis electric reference potential **112** and the test circuit electric reference potential **152**. Hence, a potential or voltage may be present across the chassis electric reference potential **112** and the test circuit electric reference potential **152**. In some aspects, the resistance, R_r, may be in-built by the manufacturer of the testing apparatus **100**. In an aspect, the resistance, R_r, may have a resistance between 250 K ohm to 280 K ohm, or about 262 K ohm.

When the test unit **150** and/or the test circuit **154** becomes faulty, leakage current may be resulted from the test circuit **154**. Accordingly, the leakage current together with the electric potential difference, V_r, between the chassis electric reference potential **112** and the test circuit electric reference potential **152** may become a power source of the electrolytic cell conditions within the testing apparatus **100** of FIG. **1**. Hence, the chassis electric reference potential **112**, the test circuit electric reference potential **152**, and the test circuit **154**, may together form a power source portion of an electrolytic cell circuit within the testing apparatus **100** of FIG. **1**.

Further, the DUT **102** being connected to the test circuit **154** may be analogous to a cathode portion of the electrolytic cell circuit within the testing apparatus **100** of FIG. **1**, and the metallic thermal contact surface **122** may be analogous to an anode portion of the electrolytic cell circuit within the testing apparatus **100** of FIG. **1**. During testing of the DUT **102**, a liquid thermal interface material, LTIM, **160** may be applied between the DUT **102** and the metallic thermal contact surface **122**. The LTIM **160** may serve as an electrolyte between the DUT **102** and the metallic thermal contact surface **122**. Hence, the LTIM **160** may be the electrolyte portion for the electrolytic cell circuit within the testing apparatus **100** of FIG. **1**.

According to various aspect, to provide electrolytic corrosion protection against the above described electrolytic cell circuit within the testing apparatus **100** of FIG. **1**, the electrical insulation arrangement **130** may be connected between the metallic thermal contact surface **122** and the chassis electric reference potential **112** to insulate the metallic thermal contact surface **122** from the chassis electric reference potential **112**. With the metallic thermal contact surface **122** electrically insulated from the chassis electric reference potential **112**, electrical conduction may be reduced and/or electrical energy flow may be prohibited between the metallic thermal contact surface **122** and the chassis electric reference potential **112**. Accordingly, flow of electrons between the metallic thermal contact surface **122**, which is analogous to the anode portion of the electrolytic cell circuit within the testing apparatus **100** of FIG. **1**, and the chassis electric reference potential **112**, which is analogous to the power source portion of an electrolytic cell circuit within the testing apparatus **100** of FIG. **1**, may be reduced or prohibited so as to minimize the effect of the electrolytic cell circuit and/or break the electrolytic cell circuit.

Therefore, providing electrolytic corrosion protection to the testing apparatus **100** of FIG. **1** may include identifying the electrolytic cell circuit within the testing apparatus **100** of FIG. **1** and providing the electrical insulation arrangement **130** into the electrolytic cell circuit so as to minimize the effect of the electrolytic cell circuit and/or break the electrolytic cell circuit by reducing or prohibiting the flow of electron within the electrolytic cell circuit and/or break the electrolytic cell circuit. Hence, the electrolytic corrosion protection system **201** of the testing apparatus **100** of FIG. **1** may include the electrical insulation arrangement **130** being inserted into the electrolytic cell circuit within the testing apparatus **100** of FIG. **1**. Thus, the electrolytic corrosion protection system **201** of the testing apparatus **100** of FIG. **1** may include the various components creating the electrolytic cell conditions within the testing apparatus **100** of FIG. **1** and the electrical insulation arrangement **130**. Accordingly, the electrolytic corrosion protection system **201** of the testing apparatus **100** of FIG. **1** may include the test circuit **154** with the test circuit electric reference potential **152**, the metallic thermal contact surface **122**, the chassis electric reference potential **122**, and the electrical insulation arrangement **130** as described with reference to FIG. **2**.

FIG. **3** shows a testing apparatus **300** as a variant of the testing apparatus **100** of FIG. **1** according to some aspects. The testing apparatus **300** of FIG. **3** may include all the features and limitations of the testing apparatus **100** of FIG. **1**. Further, the testing apparatus **300** of FIG. **3** is illustrated with the electrical insulation arrangement **130** as being a predetermined resistor **332**, R_p, connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122**. Hence, the testing apparatus **300** of FIG. **3** may include the predetermined resistor **332**, R_p, serving as a variant of the electrical insulation arrangement **130** for the testing apparatus **100** of FIG. **1**, whereby the electrical insulation arrangement **130** may be made up of electrical components. Accordingly, the electrical insulation arrangement **130** may include a circuit path **331** connecting the metallic thermal contact surface **122** to the chassis electric reference potential **122**. Further, the circuit path **331** may include the predetermined resistor **332**, R_p, connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122**.

With the predetermined resistor **332**, R_p, connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122**, the predetermined resistor **332**, R_p, serving as the electrical insulation arrangement **130** may form the tangible barrier separating the metallic thermal contact **122** and the chassis electric reference potential **112** to reduce electrical conduction and/or reduce electrical energy to a negligible amount passing through between them so as to electrically insulate the metallic thermal contact **122** from the chassis electric reference potential **112**. Hence, the predetermined resistor **332**, R_p, may reduce or prohibit the current flow from the metallic thermal contact surface **122** and the chassis electric reference potential **112**. Accordingly, the electrolytic corrosion current flow from the metallic thermal contact surface **122** to the chassis electric reference potential **112** may be significantly reduced and/or reduced to a negligible amount. Therefore, the electrolytic reaction may be significantly reduced and/or eliminated, and the possible electrolytic corrosion issue of the metallic thermal contact surface **122** as well as the possible staining issue of the DUT **102** may be solved. Thus, connecting the predetermined resistor **332**, R_p, between the metallic thermal contact surface **122** and the chassis electric reference potential **122** may provide a corrosion protection function for the testing apparatus **100**, **300**.

According to some aspects, the predetermined resistor **332**, R_p, may have a resistance of at least 500 K ohms or more, or 1 M ohms or more. According to some aspects, the predetermined resistor **332**, R_p, may have a resistance of about 500 K ohms, or 1 M ohms.

FIG. **4** shows an electrolytic corrosion protection system **401** for the testing apparatus **300** of FIG. **3** according to various aspects. Accordingly, the electrolytic corrosion protection system **401** of FIG. **4** may be a variant of the electrolytic corrosion protection system **201** of FIG. **2**. Hence, the electrolytic corrosion protection system **401** of FIG. **4** may include all the features and limitations of the electrolytic corrosion protection system **201** of FIG. **2**. As shown, the electrolytic corrosion protection system **401** of FIG. **4** may include the predetermined resistor **332**, R_p, serving as a variant of the electrical insulation arrangement **130** for the electrolytic corrosion protection system **201** of FIG. **2**. Accordingly, the electrical insulation arrangement **130** for the electrolytic corrosion protection system **401** of FIG. **4** may include the predetermined resistor **332**, R_p.

In FIG. **2** and FIG. **4**, the resistance, R_g, may be the pure resistance from the metallic thermal contact surface **122** to the chassis electric reference potential **122**. Accordingly, the resistance, R_g, may be a resistance from the metallic thermal contact surface **122** to the chassis electric reference potential **122** when there is no direct path or short circuited path from the metallic thermal contact surface **122** to the chassis electric reference potential **122**. According to some aspects, the resistance, R_g, may have a resistance of about 1.2e9 ohm. According to various aspects, instead of directly grounding the metallic thermal contact surface **122** to the chassis electric reference potential **122** for electrostatic discharge of the metallic thermal contact surface **122**, the predetermined resistor **332**, R_p, may be connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122**. As the predetermined resistor **332**, R_p, may be significantly lower than the resistance, R_g, the current flow across the resistance, R_g, may be considered to be negligible. Hence, consideration may only be required for the predetermined resistor **332**, R_p, to analysis the effect of predetermined resistor **332**, R_p, on the electrolytic cell circuit within the testing apparatus **100**, **300**.

With the predetermined resistor **332**, R_p, the electric potential difference, V_t, between the chassis electric reference potential **112** and the test circuit electric reference potential **152** may be divided across the predetermined resistor **332**, R_p, and across the LTIM **160** between the DUT **102** and the metallic thermal contact surface **122**. Accordingly, the electric potential, V_e, across the LTIM **160** between the DUT **102** and the metallic thermal contact surface **122** may be reduced significantly as compared to if the metallic thermal contact surface **122** is directly grounded to the chassis electric reference potential **122**. With the reduction of the electric potential, V_e, across the LTIM **160** between the DUT **102** and the metallic thermal contact surface **122**, the electrolytic reaction between the DUT **102** and the metallic thermal contact surface **122** may be significantly reduced or eliminated, and the possible electrolytic corrosion issue of the metallic thermal contact surface **122** as well as the possible staining issue of the DUT **102** may become negligible. Further, the predetermined resistor **332**, R_p, connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122** may still enable electrostatic discharge over time. Thus, the electrolytic corrosion protection system **401** with the predetermined resistor **332**, R_p, between the metallic thermal contact surface **122** and the chassis electric reference potential **122** may provide corrosion protection function for the testing apparatus **100**, **300** as well as continue to enable electrostatic discharge of the metallic thermal contact surface **122**.

As an example for illustration, according to some aspects, the electric potential difference, V_t, between the chassis electric reference potential **112** and the test circuit electric reference potential **152** may be between 0.8 V to 2V. With the predetermined resistor **332**, R_p, the electric potential difference, V_t, of 0.8V to 2V between the chassis electric reference potential **112** and the test circuit electric reference potential **152** may be divided across the predetermined resistor **332**, R_p, and across the LTIM **160** between the DUT **102** and the metallic thermal contact surface **122** as compared to the electric potential difference, V_t, of 0.8V to 2V between the chassis electric reference potential **112** and the test circuit electric reference potential **152** being fully applied across the LTIM **160** between the DUT **102** and the metallic thermal contact surface **122** if the metallic thermal contact surface **122** is directly grounded to the chassis electric reference potential **122**.

FIG. **5** shows a cable assembly **570** according to an aspect of the disclosure. According to an aspect, the circuit path **331** of the electrical insulation arrangement **130** of the testing apparatus **300** may be embodied as the cable assembly **570**. The cable assembly **570** may include a wire part **572**. The predetermined resistor **332**, R_p, may be disposed along the wire part **572** of the cable assembly **570**. Accordingly, the predetermined resistor **332**, R_p, may be joined as an integral segment or section of the wire part **572** of the cable assembly **570** or may be integrated into the wire part **572** of the cable assembly **570** so as to become an integral segment or section of the wire part **572** of the cable assembly **570**. According to an aspect, a cable jacket **574** may be wrapped over the wire part **572**. Accordingly, the cable jacket **574** may surround the wire part **572** including the predetermined resistor **332**, R_p. Hence, the wire part **572** with the predetermined resistor **332**, R_p, may form a core of the cable assembly **570** with the cable jacket **572** sleeved over the wire part **572**. According to an aspect, the cable assembly **570** may include a first connector **576** at an end (or a first end) of the cable assembly **570** and a second connector **578** at an opposite end (or a second end) of the cable assembly **570**. According to an aspect, the electrical insulation arrangement **130** of the testing apparatus **300** may be in the form of the cable assembly **570** with the first end of the cable assembly **570** connected to the metallic thermal contact surface **122** (or the contact member **126**) and the second end of the cable assembly **570** connected to the chassis electric reference potential **122**. For example, the first connector **576** at first end of the cable assembly **570** may be connected to the metallic thermal contact surface **122** (or the contact member **126**) and the second connector **578** at the second end of the cable assembly **570** may be connected to the chassis electric reference potential **122**. Each of the first connector **576** and the second connector **578** may include, but not limited to, a spade connector, a tab connector, a fork connector, a blade connector, or the like.

FIG. **6** shows a testing apparatus **600** as a variant of the testing apparatus **100** of FIG. **1** according to some aspects. The testing apparatus **600** of FIG. **6** may include all the features and limitations of the testing apparatus **100** of FIG. **1**. According to some aspects, the heater **128** may be an electric heater. Accordingly, when the heater **128** is an electric heater, the heater **128** may include a heater circuit **629**. Thus, the heater **128** of the testing apparatus **600** may include the heater circuit **629**. Normally, the heater circuit **629** may not be connected to the contact member **126** and/or the metallic thermal contact surface **122**. However, when the heater **128** is cracked or defective, a coil or a heater element of the heater circuit **629** may come into contact with the contact member **126** and/or the metallic thermal contact surface **122** and be electrically connected to the contact member **126** and/or the metallic thermal contact surface **122**. As a result, a leakage voltage, V_L, may be caused by the defective heater **128** due to portions of the heater circuit **629** coming into direct contact with the contact member **126** and/or the metallic thermal contact surface **122**. The heater leakage (or the leakage voltage, V_L) may cause electrical spark on the DUT **102** when the metallic thermal contact surface **122** is in contact with the DUT **102** during testing. Accordingly, the DUT **102** may be damaged by the heater leakage (or the leakage voltage, V_L). The leakage voltage, V_L, caused by the defective heater **128** may generally be significantly higher than the potential difference, V_t, between the chassis electric reference potential **112** and the test circuit electric reference potential **152**. According to some aspects, the electrical insulation arrangement **130** of the testing apparatus **600** of FIG. **6** may be configured to electrically insulate the metallic thermal contact surface **122** from the chassis electric reference potential **112** when a potential across the electrical insulation arrangement **130** is within a predetermined range. The predetermined range of the potential across the electrical insulation arrangement **130** may be less than the leakage voltage, V_L, from the heater circuit **629** of the defective heater **128**. Further, the electrical insulation arrangement **130** of the testing apparatus **600** of FIG. **6** may be configured to allow current to pass through the electrical insulation arrangement **130** when the potential across the electrical insulation arrangement **130** is outside of the predetermined range. According to an aspect, the leakage voltage, V_L, may be about 48 V or −48 V, and the predetermined range may be 10 V to −10 V.

Further, the testing apparatus **600** of FIG. **6** is illustrated with the electrical insulation arrangement **130** as being a parallel circuit **633** connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122**. Hence, the testing apparatus **600** of FIG. **6** may include the parallel circuit **633** serving as a variant of the electrical insulation arrangement **130** for the testing apparatus **100** of FIG. **1**, whereby the electrical insulation arrangement **130** may be made up of electrical components. Accordingly, the electrical insulation arrangement **130** may include the parallel circuit **663** connecting the head unit **120** and/or the contact member **126** and/or the metallic thermal contact surface **122** to the chassis electric reference potential **122**. Hence, the parallel circuit **633** may serve as the electrical insulation arrangement **130** of the testing apparatus **600**.

According to some aspects, the parallel circuit **633** may include the circuit path **331** (or a first path) with the predetermined resistor **332** connected between the metallic thermal contact surface **122** to the chassis electric reference potential **122** in a manner similar to that of the testing apparatus **300**. Accordingly, the circuit path **331** (or the first path) may connect the head unit **120** and/or the contact member **126** and/or the metallic thermal contact surface **122** to the chassis electric reference potential **122**. The predetermined resistor **332** may electrically insulate the head unit **120** and/or the contact member **126** and/or the metallic thermal contact surface **122** from the chassis electric reference potential **122** along the circuit path **331** (or the first path). According to some aspects, the parallel circuit **633** may include a second path **635** arranged to be electrically parallel to the circuit path **331** (or the first path). Hence, the second path **635** may also connect the head unit **120** and/or the contact member **126** and/or the metallic thermal contact surface **122** to the chassis electric reference potential **122**. The second path **635** may be configured in a manner such that, when the potential across the predetermined resistor **332** (or the parallel circuit **633**) is within the predetermined range, the second path **635** may be akin to an opened path whereby current does not flow through the second path **635**. Accordingly, the circuit path **331** (or the first path) may remain effective in providing electrolytic corrosion protection in the same manner by electrically insulating the metallic thermal contact surface **122** from the chassis electric reference potential **122** as previously described with reference to the testing apparatus **300** of FIG. **3** and the electrolytic corrosion protection **401** of FIG. **4** when the potential across the predetermined resistor **332** (or the parallel circuit **633**) is within the predetermined range. On the other hand, when the potential across the predetermined resistor **332** (or the parallel circuit **633**) is outside the predetermined range, the second path **635** may be akin to a closed path whereby current may flow through the second path **635**.

According to some aspects, the second path **635** may include two oppositely oriented Zener diodes **634**, **636** connected in series between the metallic thermal contact surface **122** (and/or the head unit **120** and/or the contact member **126**) and the chassis electric reference potential **122**. The two oppositely oriented Zener diodes **634**, **636** may be configured to allow current to flow through the second path **635** when the potential across the parallel circuit **633** is outside the predetermined range. The two oppositely oriented Zener diodes **634**, **636** may be configured stop current flow through the second path **635** when the potential across the parallel circuit **633** is within the predetermined range such that the circuit path **331** (or the first path) may be effective in providing electrolytic corrosion protection in the manner as previously described with reference to the testing apparatus **300** of FIG. **3** and the electrolytic corrosion protection **401** of FIG. **4**.

FIG. **7** shows an electrolytic corrosion protection system **701** for the testing apparatus **600** of FIG. **6** according to various aspects. Accordingly, the electrolytic corrosion protection system **701** of FIG. **7** may be a variant of the electrolytic corrosion protection system **201** of FIG. **2**. Hence, the electrolytic corrosion protection system **701** of FIG. **7** may include all the features and limitations of the electrolytic corrosion protection system **201** of FIG. **2**. As shown, the electrolytic corrosion protection system **701** of FIG. **7** may include the leakage voltage, V_L, from the heater circuit **629** and the parallel circuit **633** serving as a variant of the electrical insulation arrangement **130** for the electrolytic corrosion protection system **201** of FIG. **2**. Accordingly, the electrical insulation arrangement **130** for the electrolytic corrosion protection system **701** of FIG. **7** may include the leakage voltage, V_L, from the heater circuit **629** and the parallel circuit **633**.

Similar to FIG. **2** and FIG. **4**, the resistance, R_g, in FIG. **6** may be the pure resistance from the metallic thermal contact surface **122** to the chassis electric reference potential **122**. Similarly, the current flow across the resistance, R_g, may be considered to be negligible. Hence, consideration may only be required for the parallel circuit **633** to analysis the effect of the parallel circuit **633** on the electrolytic cell circuit as well as leakage voltage, V_L, from the heater circuit **629** within the testing apparatus **100**, **600**.

When the potential across the parallel circuit **633** is within the predetermined range, the oppositely oriented Zener diodes **634**, **636** connected in series along the second path **635** of the parallel circuit **633** between the metallic thermal contact surface **122** (and/or the head unit **120** and/or the contact member **126**) and the chassis electric reference potential **122** may not allow current flow and may be considered as an opened path. Accordingly, only the circuit path **331** (or the first path) with the predetermined resistor **332**, R_p, between the metallic thermal contact surface **122** (and/or the head unit **120** and/or the contact member **126**) and the chassis electric reference potential **122** may be effective. Thus, the electric potential difference, V_t, between the chassis electric reference potential **112** and the test circuit electric reference potential **152** may be divided across the predetermined resistor **332**, R_p, and across the LTIM **160** between the DUT **102** and the metallic thermal contact surface **122** for electrolytic corrosion protection as previously described with reference to the testing apparatus **300** of FIG. **3** and the electrolytic corrosion protection **401** of FIG. **4**. The predetermined range may be set based on the electric potential difference, V_t, between the chassis electric reference potential **112** and the test circuit electric reference potential **152** such that the potential across the parallel circuit **633** may likely be due to the test circuit **154** when the potential across the parallel circuit **633** is within the predetermined range. On the other hand, when the potential across the parallel circuit **633** is outside the predetermined range, it may most likely be due to the leakage voltage, V_L, from the heater circuit **629**. Accordingly, the oppositely oriented Zener diodes **634**, **636** connected in series along the second path **635** of the parallel circuit **633** between the metallic thermal contact surface **122** (and/or the head unit **120** and/or the contact member **126**) and the chassis electric reference potential **122** may be configured to allow current flow in a manner such that the second path **635** may be considered as a closed path. In this manner, current from the heater leakage may be drained so as to prevent damage to the DUT **102**.

FIG. **8** shows a cable assembly **880** according to an aspect of the disclosure. According to an aspect, the electrical insulation arrangement **130** of the testing apparatus **600** with the parallel circuit **633** may be embodied as the cable assembly **880**. The cable assembly **880** may include a first wire segment **882** and a second wire segment **884**. Each of the first wire segment **882** and the second wire segment **884** may be a strand of conductive material. The parallel circuit **633** may be connected between the first wire segment **882** and the second wire segment **884**. The first path (or the circuit path **331**) of the parallel circuit **633** with the predetermined resistor **332**, R_p, may be connected between a first node **881** and a second node **883**. The second path **635** of the parallel circuit **633** with the two oppositely oriented Zener diodes may be connected in series between the first node **881** and the second node **883**. The first path and the second path **635** may be electrically parallel paths of the parallel circuit **633**. Further, the first wire segment **882** may be connected to the first node **881** and the second wire segment **884** may be connected to the second node **883**.

According to an aspect, the first path (or the circuit path **331**) of the parallel circuit **633** may be in the form of a first wire part **886**, similar to the wire part **572** of the cable assembly **570**. The predetermined resistor **332**, R_p, may be disposed along the first wire part **886** of the cable assembly **880**. Accordingly, the predetermined resistor **332**, R_p, may be joined as an integral segment or section of the first wire part **886** of the cable assembly **880** or may be integrated into the first wire part **886** of the cable assembly **880** so as to become an integral segment or section of the first wire part **886** of the cable assembly **880**. According to an aspect, the second path **635** of the parallel circuit **633** may be in the form of a second wire part **888**. The two oppositely oriented Zener diodes **634**, **636** may be connected in series along the second wire part **888** of the cable assembly **880**. Accordingly, each of the two oppositely oriented Zener diodes **634**, **636** may be joined as an integral segment or section of the second wire part **888** of the cable assembly **880** or may be integrated into the second wire part **888** of the cable assembly **880** so as to become an integral segment or section of the second wire part **888** of the cable assembly **880**.

An end of the first wire part **886** and a corresponding end of the second wire part **888** may be connected together to form the first node **881**. An opposite end of the first wire part

886 and a corresponding opposite end of the second wire part **888** may be connected together to form the second node **883**. The first wire part **886** and the second wire part **888** may be shielded from each other. For example, the first wire part **886** and the second wire part **888** may be shielded from each other via wire insulation and/or sheath and/or shield.

According to an aspect, a cable jacket **889** may be wrapped over the first wire part **886** and the second wire part **888** to bundle the first wire part **886** and the second wire part **888** together. Accordingly, the cable jacket **574** may surround the first wire part **886** with the predetermined resistor **332**, R_p, and the second wire part **888** with the two oppositely oriented Zener diodes **634**, **636**. Hence, the first wire part **886** with the predetermined resistor **332**, R_p, and the second wire part **888** with the two oppositely oriented Zener diodes **634**, **636** may form a core of the cable assembly **880** with the cable jacket **889** sleeved over the first wire part **886** and the second wire part **888** together as a bundle. According to an aspect, the cable jacket **889** may also be wrapped over the first wire segment **882** extending away from the parallel circuit **633** from the first node **881** and the second wire segment **884** extending away from the parallel circuit **633** from the second node **883**.

According to an aspect, the cable assembly **880** may include a first connector **885** at a free end of the first wire segment **882** (or a first end of the cable assembly **880**) and a second connector **887** at a free end of the second wire segment **884** (or a second end of the cable assembly **880**). According to an aspect, the electrical insulation arrangement **130** of the testing apparatus **600** may be in the form of the cable assembly **880** with the first end of the cable assembly **880** connected to the metallic thermal contact surface **122** (and/or the contact member **126** and/or the head unit **124**) and the second end of the cable assembly **880** connected to the chassis electric reference potential **122**. For example, the first connector **885** at first end of the cable assembly **880** may be connected to the metallic thermal contact surface **122** (and/or the contact member **126** and/or the head unit **124**) and the second connector **887** at the second end of the cable assembly **880** may be connected to the chassis electric reference potential **122**. Each of the first connector **885** and the second connector **887** may include, but not limited to, a spade connector, a tab connector, a fork connector, a blade connector, or the like.

FIG. **9** shows a testing apparatus **900** as a variant of the testing apparatus **100** of FIG. **1** according to some aspects. The testing apparatus **900** of FIG. **9** may include all the features and limitations of the testing apparatus **100** of FIG. **1**. Further, the testing apparatus **900** of FIG. **9** is illustrated with the electrical insulation arrangement **130** as being one or a plurality of electrically non-conductive hardware elements **990** connected between the metallic thermal contact surface **122** and the chassis electric reference potential **122**. Hence, the testing apparatus **900** of FIG. **9** may include the one or a plurality of hardware elements **990** serving as a variant of the electrical insulation arrangement **130** for the testing apparatus **100** of FIG. **1**, whereby the electrical insulation arrangement **130** may be made up of mechanical components. The hardware elements may be made of plastic. According to some aspects, the electrical insulation arrangement **130** of the testing apparatus **900** of FIG. **9** may include one or a combination of the electrically non-conductive hardware elements **990** including, but not limited to, a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling. The one or the combination of the electrically non-conductive hardware elements **990** may be disposed at any one of a joint or mechanical connection anywhere between the metallic thermal contact surface **122** and the tester chassis **110** to establish an electrical insulation barrier between the metallic thermal contact surface **122** and the chassis electric reference potential **112**. For example, the one or the combination of the electrically non-conductive hardware elements **990** may be disposed at a joint or mechanical connection between the head unit **124** and the actuator **125**. As another example, the one or the combination of the electrically non-conductive hardware elements **990** may be disposed at a contact point between the contact member **126** and the tester chassis **110**. In some conventional testing apparatus, the nickel-plated thermal interface of the thermal head may be directly grounded to a chassis of the conventional testing apparatus via direct contact with the chassis of the conventional testing apparatus. Accordingly, the one or the combination of the electrically non-conductive hardware elements **990** may be disposed at those direct contact points to electrically insulate the metallic thermal contact surface **122** and the chassis electric reference potential **112** for electrolytic corrosion protection.

FIG. **10** shows simulation results in the form of current vs voltage curve based on the electrolytic corrosion protection system **701** of FIG. **7**. The top graph represents the simulation results in the form of current vs voltage curve for first path (or the circuit path **331**) of the parallel circuit **633** with the predetermined resistor **332**, R_p. The bottom graph represents the simulation results in the form of current vs voltage curve for second path **635** of the parallel circuit **633** with the two oppositely oriented Zener diodes **634**, **636** connected in series along the second path **635**. As clearly marked out by the boxes labelled as "Area **1**" in FIG. **10**, when the potential across the parallel circuit **633** is within the predetermined range, for example between −10V to 10V, the second path **635** clearly does not allow current to pass through. Hence, only the first path (or the circuit path **331**) of the parallel circuit **633** with the predetermined resistor **332**, R_p, may be operational and/or effective. Further, when when the potential across the parallel circuit **633** is outside the predetermined range, for example below −10V and/or above 10V, second path **635** clearly does not allow current to pass through.

FIG. **11** shows experimental results based on the electrolytic corrosion protection system of FIG. **4**. As shown, when the metallic thermal contact surface **122** is directly grounded to the chassis electric reference potential **112** without any resistor, significant corrosion and stain signature may be observed on the DUT **102**. However, when the predetermined resistor **332**, R_p, having a resistance of about 500 K ohm is connected between the metallic thermal contact surface **122** and the chassis electric reference potential **112**, a significant reduction in the corrosion and stain signature may be observed on the DUT **102**. Further, when the predetermined resistor **332**, R_p, having a resistance of about 1 M ohm is connected between the metallic thermal contact surface **122** and the chassis electric reference potential **112**, an even lesser corrosion and stain signature may be observed on the DUT **102**. Accordingly, the predetermined resistor **332**, R_p, according to various aspects may have a resistance of 500 K ohm or more, or 1 M ohm or more.

Various aspects has provided an apparatus, a system and/or a method to reduce electrolytic reaction between a metallic thermal contact surface and a DUT during DUT testing by limiting the leakage current flowing between the metallic thermal contact surface and the DUT via identifying the electrolytic cell condition within the test system and providing electrical insulation to part of the electrolytic cell circuit within the test system. In addition, various aspects have also provided protection against leakage voltage from electric heater, whereby the leakage voltage may be much higher than the electrolytic cell potential. Various aspects have also solved the electrolytic corrosion issues without having to be dependent on the plating quality of the metallic thermal contact surface. Various aspects have also prolonged the life span of existing nickel plated metallic thermal contact member while avoiding the need to replace the existing nickel plated metallic thermal contact member with chrome plated replacement, thereby achieving cost-saving.

In the following, various examples are described that may refer to one or more aspects of the disclosure.

In Example 1, an apparatus is disclosed including a tester chassis connected to a chassis electric reference potential for electrostatic discharge grounding of the tester chassis; a thermal head assembly coupled to the tester chassis, the thermal head assembly having a metallic thermal contact surface; and an electrical insulation arrangement disposed between the metallic thermal contact surface and the chassis electric reference potential to electrically insulate the metallic thermal contact from the chassis electric reference potential.

In Example 2, the apparatus of Example 1 is disclosed further including a device-under-test (DUT) connector connectable with a DUT, wherein the thermal head assembly is operable to move the metallic thermal contact surface to contact the DUT when the DUT is connected to the DUT connector; and a test unit connected to the DUT connector for communicating with the DUT when the DUT is connected to the DUT connector, the test unit having a test circuit electric reference potential serving as a circuit ground for the test unit, wherein an electric potential difference exists between the chassis electric reference potential and the test circuit electric reference potential.

In Example 3, the apparatus of Example 1 is disclosed, wherein the electrical insulation arrangement includes a circuit path connecting the metallic thermal contact surface to the chassis electric reference potential, wherein the circuit path includes a predetermined resistor connected between the metallic thermal contact surface and the chassis electric reference potential.

In Example 4, the apparatus of Example 3 is disclosed, wherein the circuit path is embodied as a cable.

In Example 5, the apparatus of Example 4 is disclosed, wherein the cable includes a wire part with the predetermined resistor disposed along the wire part; and a cable jacket wrapped over the wire part.

In Example 6, the apparatus of Example 5 is disclosed, wherein the cable includes a first connector at an end of the cable, and a second connector at an opposite end of the cable.

In Example 7, the apparatus of Example 1 is disclosed, wherein the electrical insulation arrangement includes one or a combination of electrically non-conductive hardware elements including a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling disposed at any one of a joint or mechanical connection anywhere between the metallic thermal contact surface and the tester chassis to establish an electrical insulation barrier between the metallic thermal contact surface and the chassis electric reference potential.

In Example 8, the apparatus of Example 1 is disclosed, wherein the thermal head assembly includes a head unit including a contact member having the metallic thermal contact surface; and an electric heater coupled to the contact member.

In Example 9, the apparatus of Example 8 is disclosed, wherein the electrical insulation arrangement is configured to electrically insulate the metallic thermal contact from the chassis electric reference potential when a potential across the electrical insulation arrangement is within a predetermined range, the electrical insulation arrangement includes a parallel circuit connecting the head unit to the chassis electric reference potential, wherein the parallel circuit includes a first path with a predetermined resistor connected between the head unit and the chassis electric reference potential, and a second path with two oppositely oriented Zener diodes connected in series between the head unit and the chassis electric reference potential, the first path and the second path being electrically parallel paths.

In Example 10, the apparatus of Example 9 is disclosed, wherein the parallel circuit is embodied as a cable with a first end of the cable connected to the head unit and a second end of the cable connected to the chassis electric reference potential.

In Example 11, the apparatus of Example 10 is disclosed, wherein the cable includes a first wire part with the predetermined resistor disposed along the first wire part; a second wire part with the two oppositely oriented Zener diodes connected in series along the second wire part, wherein an end of the first wire part and a corresponding end of the second wire part are connected together to form a first node and an opposite end of the first wire part and a corresponding opposite end of the second wire part are connected together to form a second node, wherein the first wire part and the second wire part are shielded from each other; and a cable jacket wrapped over the first wire part and the second wire part to bundle the first wire part and the second wire part together.

In Example 12, the apparatus of Example 11 is disclosed, wherein the cable includes a first connector at the first end of the cable, the first connector being connected to the first node, and a second connector at the second end of the cable, the second connector being connected to the second node.

In Example 13, the apparatus of Example 8 is disclosed, wherein electrical insulation arrangement includes one or a combination of electrically non-conductive hardware elements including a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling disposed at any one of a joint or mechanical connection anywhere between the head unit and the tester chassis to establish an electrical insulation barrier between the metallic thermal contact surface and the chassis electric reference potential.

In Example 14, a cable assembly is disclosed including a first wire segment; a second wire segment; and a parallel circuit connected between the first wire segment and the second wire segment, the parallel circuit having a first path with a predetermined resistor connected between a first node and a second node, and a second path with two oppositely oriented Zener diodes connected in series between the first node and the second node, the first path and the second path being electrically parallel paths, wherein the first wire segment is connected to the first node and the second wire segment is connected to the second node.

In Example 15, the cable assembly of Example 14 is disclosed further including a first wire part with the predetermined resistor disposed along the first wire part; a second wire part with the two oppositely oriented Zener diodes connected in series along the second wire part, wherein an end of the first wire part and a corresponding end of the second wire part are connected together to form the first node and an opposite end of the first wire part and a corresponding opposite end of the second wire part are connected together to form the second node, wherein the first wire part and the second wire part are shielded from each other; and a cable jacket wrapped over the first wire part and the second wire part to bundle the first wire part and the second wire part together.

In Example 16, the cable assembly of Example 15 is disclosed further including a first connector at a free end of the first wire segment, and a second connector at a free end of the second wire segment.

In Example 17, a system is disclosed including a test circuit configured to receive a device-under-test (DUT) and to run test programs on the DUT, the test circuit having a test circuit electric reference potential serving as a circuit ground for the test circuit; a metallic thermal contact surface configured to contact the DUT connected to the test circuit and operable to regulate a temperature of the DUT when in contact with the DUT during testing; a chassis electric reference potential for electrostatic discharge grounding of a tester chassis; and an electrical insulation arrangement connected between the metallic thermal contact surface and the chassis electric reference potential to insulate the metallic thermal contact surface from the chassis electric reference potential, wherein an electric potential difference exists between the chassis electric reference potential and the test circuit electric reference potential.

In Example 18, the system of Example 17 is disclosed further including a heater circuit configured to control a temperature of the metallic thermal contact surface for regulating the temperature of the DUT when in contact with the DUT during testing.

In Example 19, the system of Example 18 is disclosed, wherein the electrical insulation arrangement is configured to electrically insulate the metallic thermal contact from the chassis electric reference potential when a potential across the electrical insulation arrangement is within a predetermined range, the electrical insulation arrangement includes a parallel circuit connecting the metallic thermal contact surface to the chassis electric reference potential, wherein the parallel circuit includes a first path with a predetermined resistor connected between the metallic thermal contact surface and the chassis electric reference potential, and a second path with two oppositely oriented Zener diodes connected in series between the metallic thermal contact surface and the chassis electric reference potential, the first path and the second path being electrically parallel paths.

In Example 20, the system of Example 17 is disclosed, wherein the electrical insulation arrangement includes one or a combination of electrically non-conductive hardware elements including a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling disposed at any one of a joint or mechanical connection anywhere between the metallic thermal contact surface and the tester chassis to establish an electrical insulation barrier between the metallic thermal contact surface and the chassis electric reference potential.

While the disclosure has been particularly shown and described with reference to specific aspects, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the disclosure as defined by the appended claims. The scope of the disclosure is thus indicated by the appended claims and all changes, which come within the meaning and range of equivalency of the claims, are therefore intended to be embraced.

What is claimed is:

1. An apparatus comprising:

a tester chassis connected to a chassis electric reference potential for electrostatic discharge grounding of the tester chassis;

a thermal head assembly coupled to the tester chassis, the thermal head assembly having a metallic thermal contact surface; and

an electrical insulation arrangement disposed between the metallic thermal contact surface and the chassis electric reference potential to electrically insulate the metallic thermal contact from the chassis electric reference potential.

2. The apparatus as claimed in claim **1**, further comprising

a device-under-test (DUT) connector connectable with a DUT, wherein the thermal head assembly is operable to move the metallic thermal contact surface to contact the DUT when the DUT is connected to the DUT connector; and

a test unit connected to the DUT connector for communicating with the DUT when the DUT is connected to the DUT connector, the test unit having a test circuit electric reference potential serving as a circuit ground for the test unit,

wherein an electric potential difference exists between the chassis electric reference potential and the test circuit electric reference potential.

3. The apparatus as claimed in claim **1**, wherein the electrical insulation arrangement comprises

a circuit path connecting the metallic thermal contact surface to the chassis electric reference potential, wherein the circuit path comprises a predetermined resistor connected between the metallic thermal contact surface and the chassis electric reference potential.

4. The apparatus as claimed in claim **3**, wherein the circuit path is embodied as a cable.

5. The apparatus as claimed in claim **4**, wherein the cable comprises

a wire part with the predetermined resistor disposed along the wire part; and

a cable jacket wrapped over the wire part.

6. The apparatus as claimed in claim **5**, wherein the cable comprises

a first connector at an end of the cable, and

a second connector at an opposite end of the cable.

7. The apparatus as claimed in claim **1**, wherein the electrical insulation arrangement comprises one or a combination of electrically non-conductive hardware elements including a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling disposed at any one of a joint or mechanical connection anywhere between the metallic thermal contact surface and the tester chassis to establish an electrical insulation barrier between the metallic thermal contact surface and the chassis electric reference potential.

8. The apparatus as claimed in claim **1**, wherein the thermal head assembly comprises a head unit comprising

a contact member having the metallic thermal contact surface; and

an electric heater coupled to the contact member.

9. The apparatus as claimed in claim **8**, wherein the electrical insulation arrangement is configured to electrically insulate the metallic thermal contact from the chassis electric reference potential when a potential across the electrical insulation arrangement is within a predetermined range, the electrical insulation arrangement comprises

a parallel circuit connecting the head unit to the chassis electric reference potential, wherein the parallel circuit comprises

a first path with a predetermined resistor connected between the head unit and the chassis electric reference potential, and

a second path with two oppositely oriented Zener diodes connected in series between the head unit and the chassis electric reference potential, the first path and the second path being electrically parallel paths.

10. The apparatus as claimed in claim **9**, wherein the parallel circuit is embodied as a cable with a first end of the cable connected to the head unit and a second end of the cable connected to the chassis electric reference potential.

11. The apparatus as claimed in claim **10**, wherein the cable comprises

a first wire part with the predetermined resistor disposed along the first wire part;

a second wire part with the two oppositely oriented Zener diodes connected in series along the second wire part, wherein an end of the first wire part and a corresponding end of the second wire part are connected together to form a first node and an opposite end of the first wire part and a corresponding opposite end of the second wire part are connected together to form a second node, wherein the first wire part and the second wire part are shielded from each other; and

a cable jacket wrapped over the first wire part and the second wire part to bundle the first wire part and the second wire part together.

12. The apparatus as claimed in claim **11**, wherein the cable comprises

a first connector at the first end of the cable, the first connector being connected to the first node, and

a second connector at the second end of the cable, the second connector being connected to the second node.

13. The apparatus as claimed in claim **8**, wherein the electrical insulation arrangement comprises one or a combination of electrically non-conductive hardware elements including a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling disposed at any one of a joint or mechanical connection anywhere between the head unit and the tester chassis to establish an electrical insulation barrier between the metallic thermal contact surface and the chassis electric reference potential.

14. A cable assembly comprising:

a first wire segment;

a second wire segment; and

a parallel circuit connected between the first wire segment and the second wire segment, the parallel circuit having

a first path with a predetermined resistor connected between a first node and a second node, and

a second path with two oppositely oriented Zener diodes connected in series between the first node and the second node, the first path and the second path being electrically parallel paths,

wherein the first wire segment is connected to the first node and the second wire segment is connected to the second node.

15. The cable assembly as claimed in claim **14**, further comprising

a first wire part with the predetermined resistor disposed along the first wire part;

a second wire part with the two oppositely oriented Zener diodes connected in series along the second wire part, wherein an end of the first wire part and a corresponding end of the second wire part are connected together to form the first node and an opposite end of the first wire part and a corresponding opposite end of the second wire part are connected together to form the second node, wherein the first wire part and the second wire part are shielded from each other; and

a cable jacket wrapped over the first wire part and the second wire part to bundle the first wire part and the second wire part together.

16. The cable assembly as claimed in claim **15**, further comprising

a first connector at a free end of the first wire segment, and

a second connector at a free end of the second wire segment.

17. A system comprising:

a test circuit configured to receive a device-under-test (DUT) and to run test programs on the DUT, the test circuit having a test circuit electric reference potential serving as a circuit ground for the test circuit;

a metallic thermal contact surface configured to contact the DUT connected to the test circuit and operable to regulate a temperature of the DUT when in contact with the DUT during testing;

a chassis electric reference potential for electrostatic discharge grounding of a tester chassis; and

an electrical insulation arrangement connected between the metallic thermal contact surface and the chassis electric reference potential to insulate the metallic thermal contact surface from the chassis electric reference potential,

wherein an electric potential difference exists between the chassis electric reference potential and the test circuit electric reference potential.

18. The system as claimed in claim **17**, further comprising

a heater circuit configured to control a temperature of the metallic thermal contact surface for regulating the temperature of the DUT when in contact with the DUT during testing.

19. The system as claimed in claim **18**, wherein the electrical insulation arrangement is configured to electrically insulate the metallic thermal contact from the chassis electric reference potential when a potential across the electrical insulation arrangement is within a predetermined range, the electrical insulation arrangement comprises

a parallel circuit connecting the metallic thermal contact surface to the chassis electric reference potential, wherein the parallel circuit comprises

a first path with a predetermined resistor connected between the metallic thermal contact surface and the chassis electric reference potential, and

a second path with two oppositely oriented Zener diodes connected in series between the metallic thermal contact surface and the chassis electric reference potential, the first path and the second path being electrically parallel paths.

20. The system as claimed in claim **17**, wherein the electrical insulation arrangement comprises one or a combination of electrically non-conductive hardware elements including a non-conductive spacer, a non-conductive washer, a non-conductive fastener, a non-conductive linkage, a non-conductive connector, or a non-conductive coupling disposed at any one of a joint or mechanical connection anywhere between the metallic thermal contact surface and the tester chassis to establish an electrical insulation barrier between the metallic thermal contact surface and the chassis electric reference potential.

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